COSEWIC
Assessment and Status Report

on the

Oregon Forestsnail
Allogona townsendiana

in Canada

ENDANGERED
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Oregon Forestsnail

Scientific name
Allogona townsendiana

Status
Endangered

Reason for designation
This large land snail is endemic to western North America. In Canada, it occurs mainly in the Lower Fraser Valley, the most densely populated and highly fragmented region of British Columbia. It also has been found at a single site on Vancouver Island. Habitat loss due to residential and commercial development continues to fragment and isolate remaining populations.

Occurrence
British Columbia

Status history
Designated Endangered in November 2002. Status re-examined and confirmed in May 2013.

COSEWIC
Executive Summary

Oregon Forestsnail
Allogona townsendiana

Wildlife Species Description and Significance

Oregon Forestsnail (Escargot-forestier de Townsend) is a member of a large and diverse family (Polygyridae) of North American land snails. The shell of mature individuals is pale brown or straw-yellow, round and flattened, and ranges from 28–35 mm in diameter. The apertural lip of the shell is pale and broadly expanded. Unlike some related species, the aperture (shell opening) lacks tooth-like structures (denticles). The shell is smooth and without hair-like projections as in some related snails.

Relatively few native, large land snails inhabit coastal forests in British Columbia (BC). The presence of the Oregon Forestsnail in Canada is of both scientific and conservation interest, as populations at the northern limits of their geographical range might possess unique adaptations.

Distribution

Oregon Forestsnail occurs in the western Cascade Range, Puget Trough, and eastern lowlands of the Olympic Peninsula in the United States north into extreme southwestern BC. Oregon Forestsnail are found from Tsawwassen through the Lower Mainland towards Langley, with most records occurring within the Lower Fraser Valley in the Mission, Abbotsford, Chilliwack area, and as far east as Hope. There is one outlying site on southern Vancouver Island near Crofton.

Habitat

Oregon Forestsnail occupies mixed-wood and deciduous forest habitat, typically dominated by Bigleaf Maple, Balsam Poplar and scattered Western Redcedar. Many records are from riparian habitats and forest edges, where dense cover of low herbaceous native vegetation is typically present. The presence of Oregon Forestsnail is correlated with the presence of Stinging Nettle, although the specific connection between these two species has not been studied. Stinging Nettle is known to have high levels of calcium, which is necessary for healthy shell growth in snails. All known Canadian Oregon Forestsnail populations are from habitats less than 360 m above sea level.

Biology

Oregon Forestsnail is hermaphroditic. The surface activity of the snails appears to peak in spring and early summer, coinciding with mating and oviposition. They appear to be slow maturing and long-lived, reaching maturity at two years and living from five to eight years. Their dispersal ability is likely poor, based on the scattered distribution of the species throughout its geographic range.

Population Sizes and Trends

Increased search effort since the initial species' assessment by COSEWIC in 2002 has resulted in numerous additional records of Oregon Forestsnail. There is no information available on population size from previously known sites to allow the assessment of trends. The Canadian population for Oregon Forestsnail is estimated to be in the 100,000s.

Fifty-two of the 66 known sites (78.8%) were assessed as fragmented and isolated. At least 50 sites are less than 5 ha in size and/or are subject to urban development within the next 10 years. These sites are isolated by distances of more than 1 km of unsuitable habitat as a result of past land development (since 2002) and most likely will not be able to maintain a viable snail population in the future. While only 108 ha of the 328 ha (33%) of the biological area of occupancy of known mapped sites is fragmented and isolated, nearly 80% of the total number of known sites and 67% of the 75 occupied 2 km x 2 km grid cells are considered too small and isolated to maintain viable populations. These remnant fragments are indicative of larger pieces of habitat that once existed.

Threats and Limiting Factors

The Canadian range of Oregon Forestsnail coincides with the most densely populated and highly fragmented region of BC. The most serious threat to Oregon Forestsnail is continuing residential and commercial development, resulting in further fragmentation and isolation of populations. Snails have limited dispersal capabilities and cannot move between habitat patches or colonize suitable habitat if there are barriers to dispersal. Additional threats include recreational activities and invasive non-native/alien species.

Protection, Status, and Ranks

Oregon Forestsnail is listed as Endangered under the federal *Species at Risk Act* and a BC Recovery Plan is completed. The species is recommended for listing as Identified Wildlife under the BC *Forest and Range Practices Act,* the BC *Wildlife Act* and *Wildlife Amendment Act.* Oregon Forestsnail habitat is protected within parks and protected areas by the BC *Park Act* and *Ecological Reserves Act*. Where Oregon Forestsnail occurs in parks and properties owned by local governments, land managers are aware of the snail and its habitat needs although efficacy of protection varies. The provincial *Water Act* and Riparian Areas Regulation under the provincial *Fisheries Act* have the potential to indirectly protect Oregon Forestsnail habitat.

Oregon Forestsnail is critically imperilled-imperilled (S1S2) in BC and is nationally ranked in Canada as critically-imperilled-imperilled (N1N2). The global conservation status rank is vulnerable-apparently secure (G3G4). In Washington State the species has a conservation status rank of vulnerable-apparently secure (S3S4) but it is not ranked (SNR) in Oregon State.

TECHNICAL SUMMARY

Allogona townsendiana
Oregon Forestsnail Escargot-forestier de Townsend
Range of occurrence in Canada (province/territory/ocean): British Columbia

Demographic Information

Generation time (usually average age of parents in the population)	4-6 yrs, average at least 5 years
Is there an observed, inferred, or projected continuing decline in number of mature individuals?	Yes, inferred due to habitat loss
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations	Unknown
Observed, estimated, inferred or suspected percent reduction in total number of mature individuals over the last 10 years or 3 generations.	Yes inferred, due to cumulative habitat loss but magnitude unknown
Projected or suspected percent reduction in total number of mature individuals over the next 10 years or 3 generations].	Magnitude of suspected percent decline due to habitat loss uncertain
Observed, estimated, inferred or suspected percent reduction in total number of mature individuals over any 10 years or 3 generations period, over a time period including both the past and the future.	Magnitude of inferred decline due to cumulative habitat loss uncertain
Are the causes of the decline clearly reversible and understood and ceased?	Causes understood but not reversible and not ceased.
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	3,313 km² (including Vancouver Island site)
Index of area of occupancy (IAO) (Always report 2x2 grid value).	300 km² based on known sites, likely larger
Is the total population severely fragmented? 52 of the 66 known sites (78.8%) and 50 of the 75 known occupied 2 km x 2 km grid squares (66.7%) were assessed as fragmented and isolated. At least 50 sites are less than 5 ha in size and/or subject to urban development within the next 10 years. These sites are isolated by distances of more than 1 km of unsuitable habitat as a result of past land development and most likely will not be able to maintain a viable snail population in the future.	Yes.
Number of locations* The number of locations is estimated to be much greater than 10 if each occupied site with a different land owner is a location. Number of locations in the last ten years is likely to have declined with the loss of at least 17 sites in the previous ten years.	>>> 10
Is there an observed, inferred, or projected continuing decline in extent of occurrence?	yes, decline is observed and is expected to continue due to habitat conversion.

* See Definitions and Abbreviations on COSEWIC Web site and IUCN 2010 for more information on this term.

Is there an observed, inferred, or projected continuing decline in index of area of occupancy?	yes, decline is observed and is expected to continue due to habitat conversion.
Is there an observed, inferred, or projected continuing decline in number of populations?	yes, decline is observed and is expected to continue due to habitat conversion.
Is there an observed, inferred, or projected continuing decline in number of locations*?	yes, decline is observed and is expected to continue due to habitat conversion.
Is there an observed, inferred, or projected continuing decline in area, extent and/or quality of habitat?	yes declines in area, extent and quality of habitat are observed and are expected to continue
Are there extreme fluctuations in number of populations?	no
Are there extreme fluctuations in number of locations*?	no
Are there extreme fluctuations in extent of occurrence?	no
Are there extreme fluctuations in index of area of occupancy?	no

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Steensma *et al.* (2009) provide population estimates among the four study areas within the TWU-ESA ranging from seven to 47 snails in four 24-m^2 sampling sites with an overall mean population density of 1.0 snail/m^2.	N/A
Chilliwack site: (Hawkes and Gatten 2011) estimated density of Oregon Forestsnail was highest in riparian habitats (0.14 snail/m^2) and second-growth mixed deciduous forests (0.13 snail/m^2). These data were not gathered in the breeding season, which is considered ideal timing; however, they were collected in the wet fall when snails are known to be active and visible. Until a survey is repeated in spring mating season, the Chilliwack results should be treated with uncertainty.	N/A
Total The respective density estimates above were multiplied by the total biological area (m^2) of mapped occurrences (~ 3,278,300 m^2) (see Table 1; BC Conservation Data Centre 2013) and yield a range of 426,000 to 3.3 million individuals.	100,000s of individuals

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not calculated

Threats (actual or imminent, to populations or habitats)

The predominant threat to Oregon Forestsnail is ongoing habitat loss from residential and commercial development. Habitat conversion of riparian areas and low elevation forest habitats combined with a clumped natural distribution pattern suggest that populations are becoming more fragmented. Additional major threats include the increased spread of invasive non-native/alien species at all sites and ongoing recreational activities at many of the sites within parks and/or adjacent to more urban areas.

See Definitions and Abbreviations on COSEWIC Web site and IUCN 2010 for more information on this term.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Global conservation status rank is G3G4 (vulnerable-apparently secure) Washington State S3S4 (vulnerable-apparently secure) Oregon State SNR (status not ranked).	
Is immigration known or possible?	Not known.
Would immigrants be adapted to survive in Canada?	Yes.
Is there sufficient habitat for immigrants in Canada? Canadian habitat is under severe threat of loss and decline in quality from residential and commercial development, invasive species, and recreational activities.	Unlikely.
Is rescue from outside populations likely?	Yes, but minimal at natural areas along the US border

Data-Sensitive Species

Is this a data-sensitive species? Yes.

Status History

Designated Endangered in November 2002. Status re-examined and confirmed in May 2013.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v)
Reasons for designation: This large land snail is endemic to western North America. In Canada it occurs mainly in the Lower Fraser Valley, the most densely populated and highly fragmented region of British Columbia. It also has been found at one site on Vancouver Island. Habitat loss due to residential and commercial development continues to fragment and isolate remaining populations.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. While continuing loss of mature individuals due to declines in IAO, EO, and quality of habitat is expected in the future both within the next 10 years and 3 generations and beyond, the rate of loss cannot be quantified using available data.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v) where both the EO (3,313 km^2) and IAO (300 km^2) of known sites are below the thresholds for Endangered (<5,000 and <500 km^2, respectively). While the number of locations based on the threat of urban and commercial development as well as land ownership exceeds the threshold (10 or fewer locations), nearly 80% of the known sites are not viable. Therefore the species is considered severely fragmented (subcriterion a) and all subcriteria under (b) are applicable: continued loss and fragmentation of habitat will lead to further declines in EO, IAO, area, extent and quality of habitat, number of locations and populations, and ultimately to number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. The actual number of mature individuals is unknown and while the number of mature individuals is expected to decrease in the future, the rate cannot be quantified at this time.
Criterion D (Very Small or Restricted Total Population): Not applicable. The actual number of mature individuals is unknown but probably exceeds the thresholds (< 1000 for Threatened); the IAO and number of locations also exceed the typical thresholds.
Criterion E (Quantitative Analysis): Not applicable. No population viability analyses have been done.

PREFACE

Oregon Forestsnail (*Allogona townsendiana*) was assessed by COSEWIC in 2002 as Endangered. Since the first status report was prepared, new information on the distribution and habitat, habitat trends, threats and limiting factors has been gathered through inventory and research. Studies on life history, including clutch size and egg-laying sites, overwintering and aestivation sites, home range, food preferences, and association with Stinging Nettle (*Urtica dioica*), also have been completed.

From 2000 – 2011 substantial search effort for Oregon Forestsnail has resulted in additional sites within the species' range in British Columbia (BC). Search effort has focused on the edges of the range yet the range has not been substantially expanded. The historical record on Vancouver Island at Westholme (1903) near Crofton was confirmed in 2003 and again in 2009.

Since 2000, over 1080 sites have been surveyed for gastropods within the range of Oregon Forestsnail. In 2002 there were 37 known sites for Oregon Forestsnail, and as of 2011 there are 66 known occupied sites. Site abundance ranges from one individual (at least 17 sites) to counts greater than 20 snails (9 sites). The largest number of observations at one time is 670 individuals at Colony Farm Regional Park.

While more sites have been found to be occupied by the snail, due to increased search effort as a consequence of listing as Endangered under the *Species at Risk Act*, 52 of the 66 known sites (78.8%) and 50 of the 75 occupied 2 km x 2 km grid cells (66.7%) were assessed as fragmented and isolated. At least 50 sites are less than 5 ha in size and/or are subject to urban development within the next 10 years (see **THREATS AND LIMITING FACTORS**). These sites are isolated by distances of more than 1 km of unsuitable habitat as a result of past land development (since 2002) and most likely will not be able to maintain a viable snail population in the future.

The most serious and plausible threat identified in the original status report – urban development – continues to further fragment and eliminate Oregon Forestsnail habitat in the densely populated Lower Fraser Valley region of BC.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Allogona townsendiana* (I. Lea, 1838)

Classification:	Kingdom	Animalia
	Phylum	Mollusca
	Class	Gastropoda
	Subclass	Pulmonata
	Order	Stylommatophora
	Suborder	Sigmurethra
	Family	Polygyridae
	Subfamily	Polygyrinae
	Tribe	Allogonini
	Genus	*Allogona*
	Subgenus	*Dysmedoma*
	Species	*Allogona townsendiana*

Synonyms: The most recent compilation of the complete synonymy is in Pilsbry (1940). Subsequently, Branson (1977) lists *Allogona townsendiana brunnea* Vanatta, 1924 and Forsyth (2004) lists *Allogona townsendiana frustrationis* Pilsbry, 1940 as additional synonyms.

Subspecies: No subspecies of *A. townsendiana* are recognized (Forsyth 2004; Forsyth pers. comm. 2011).

English Name: Oregon Forestsnail

French Name: Escargot-forestier de Townsend

Type Localities: *Helix townsendiana* – near junction of Willamette and Columbia rivers, Washington; *A. t. brunnea* – Columbia River near Kelso, Washington; *A. t. frustrationis* North Head, Washington.

Taxonomic Background and Similarities: Oregon Forestsnail (*Allogona townsendiana*) belongs to the family Polygyridae, a large and diverse group of North American terrestrial snails (Pilsbry 1940; Emberton 1994, 1995). The species has been treated as a member of the genus *Allogona* since Pilsbry (1939). The genus *Allogona* is currently believed (Pilsbry 1940; Emberton 1995; Turgeon *et al.* 1998) to contain four species: Selway Forestsnail, *A. lombardii* A.G. Smith 1943; Broad-banded Forestsnail, *A. profunda* (Say, 1821); Idaho Forestsnail, *A. ptychophora* (A.D. Brown, 1870); and Oregon Forestsnail. All three western species — *A. lombardii*, *A. ptychophora* and *A. townsendiana* — belong to the anatomically distinct subgenus *Dysmedoma* (Pilsbry 1939, 1940; Emberton 1995).

In Canada, *Allogona* is represented by three species: Oregon Forestsnail, Idaho Forestsnail and Broad-banded Forestsnail. Some British Columbia (BC) shells attributed to Selway Forestsnail by Smith (1943) and thought doubtful by La Rocque (1953) are likely Idaho Forestsnail (Forsyth 1999a).

Morphological Description

Oregon Forestsnail (Figures 1 and 2) is a large land snail (adult shell diameter, 20–35 mm; 5¼ – 6 whorls) with a slightly flattened and globular shell (Forsyth 2004).The shell varies from straw-yellow, amber to light reddish brown and has fine, wavy spiral striae; irregular, light-coloured, wrinkle-like axial riblets and an overall irregular dimpled sculpture (Forsyth 2004). The outer organic protein layer (periostracum) lacks hair-like structures present in some other polygyrids. The periostracum and spiral striae erode away in some individuals, leaving the shells grey-white. The lip of the aperture (opening) of the shell is thick and outwardly flared. Unlike some related species, there is no denticle inside the aperture.

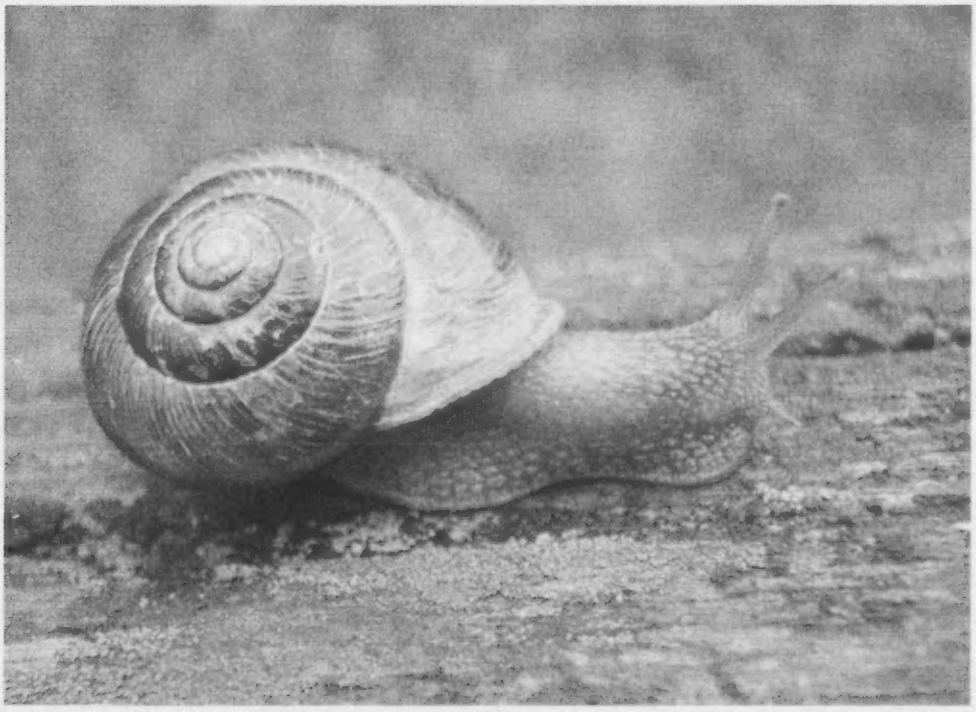

Figure 1. Oregon Forestsnail (*Allogona townsendiana*) adult, June 11, 2010, Colony Farm Metro Vancouver Regional Park. Photograph by Jennifer Heron.

Figure 2. Oregon Forestsnail (*Allogona townsendiana*) underside of the shell showing the white apertural lip, June 11, 2010, Colony Farm Regional Park. Photograph by Jennifer Heron.

Steensma *et al.* (2009) studied and described Oregon Forestsnail eggs. Eggs are round, globose, opaque and greyish-white, slightly flattened and with a grainy texture and are laid singly or in clusters. Egg clutches laid in captivity average 34 eggs with each egg 2.5 – 4.0 mm in diameter. On average, first eggs laid in captivity were generally larger than last eggs in the clutch.

Juvenile Oregon Forestsnails have thinner, translucent shells and are not eroded. They have a thin unflared lip. Newly hatched juveniles are 2 mm diameter, and reach 3 – 3.5 mm after six weeks (Steensma *et al.* 2009). At 4 mm, juveniles were able to form an epiphragm (plug of dried mucus) in dry weather and by two months old were 5 mm diameter (Steensma *et al.* 2009).

Further morphological descriptions of Oregon Forestsnail are given by Pilsbry (1940), Kozloff (1976), and Forsyth (2004). Oregon Forestsnail is relatively easily distinguished from other land snails within its BC range; most confusion is with immature individuals. Comparisons with other similar land snails within the same geographic range as Oregon Forestsnail are detailed in Forsyth (2004).

Population Spatial Structure and Variability

In Canada, the spatial structure and variability of Oregon Forestsnail populations has not been studied. Similarly, no genetic studies have occurred on the species.

Designatable Units

Oregon Forestsnail has one designatable unit within Canada. No subspecies are recognized. The species occurs entirely in the COSEWIC (2011) Pacific National Ecological Area and there is no information on population genetic structure among sites. There also are no data on discreteness or evolutionary significance among populations.

Special Significance

Relatively few large, native land snails live in the coastal forests of BC, and Oregon Forestsnail is a valuable component of the biodiversity within these ecosystems. Land snails sequester calcium and other minerals from the environment, required for the development of their shells.

Oregon Forestsnail is used as an interpretive tool by conservation organizations to represent the importance of rare and endangered species within the lowland wet riparian broadleaf forests remaining throughout the Lower Fraser Valley. Conservation organizations such as the Fraser Valley Conservancy (MacMillan pers. comm. 2012) and South Coast Conservation Program (Robbins pers. comm. 2012; Welstead pers. comm. 2012) use Oregon Forestsnail when informing private landowners about stewardship opportunities.

Aboriginal Traditional Knowledge on this species is unknown as there is no information on Oregon Forestsnail and its importance to First Nations. However, there is some literature on the cultural significance of Stinging Nettle (*Urtica dioica*), which appears to be a habitat associate with Oregon Forestsnail (see **Habitat Requirements** and **Interspecific Interactions**).

Oregon Forestsnail, as with other herbivorous land snails, perform important ecological functions in forest ecosystems as decomposers and consumers of live and decaying plant matter (see Mason 1970; Richter 1979, 1980a,b; Gervais *et al.* 1998).

Some species may also function as dispersal agents for plant seeds (Gervais *et al.* 1998), fungal spores (Burke *et al.* 1999) and lichen (Boch *et al.* 2011). Burke (1999) suggested that Puget Oregonian (*Cryptomastix devia*) might aid in the dispersal of fungal spores, including mycorrhizal fungi that form tree-root associations, which promote healthy tree growth. Oregon Forestsnail is similar in size to Puget Oregonian and would likely play a similar role. The significance of the Oregon Forestsnail in such processes is unknown but may be considerable given the species' relatively large size and local abundance in suitable moist habitats.

Oregon Forestsnail can be observed in high abundance at some sites (BC Conservation Data Centre 2013) and may provide a significant food source for other invertebrates, birds and/or small mammals. In particular, the concentration of calcium within shells is likely a significant source for other invertebrates.

In Canada, Oregon Forestsnail occurs at the northern limits of its range, and it may therefore hold distinctive adaptations and be of special scientific and conservation interest (Scudder 1989).

DISTRIBUTION

Global Range

The global range of Oregon Forestsnail is entirely within western North America (Figure 3). The northernmost extent of its range is in southwestern BC and southeastern Vancouver Island. The range extends south through the Puget Trough and Willamette Valley in Washington State to west-central Oregon. The easternmost records are west of Hope in BC, south-central Washington and north-central Oregon in the Columbia River Valley.

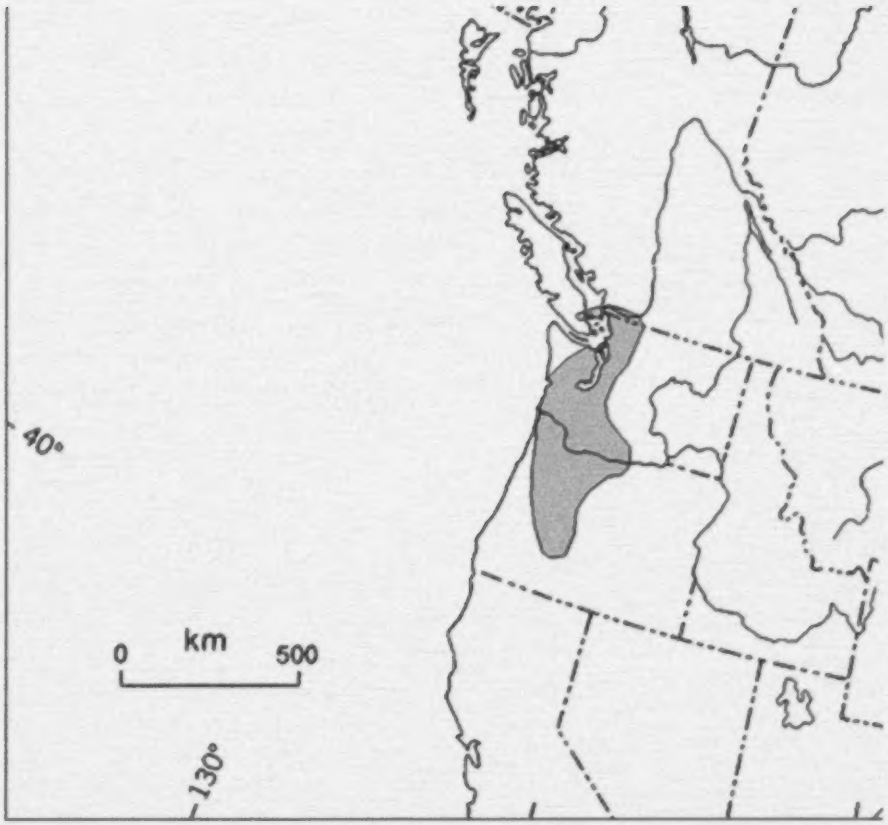

Figure 3. Global range of Oregon Forestsnail (*Allogona townsendiana*), based on Pilsbry (1940, figure 508) and Canadian records (BC Conservation Data Centre 2013). Originally published in COSEWIC (2002).

Canadian Range

In Canada, Oregon Forestsnail is restricted to southwestern BC (Figure 4). The species ranges within the Lower Fraser Valley from Tsawwassen (western-most record) through the municipalities of Burnaby, Delta, Surrey, Langley, Coquitlam, Mission, Abbotsford, and Chilliwack to Hope (eastern-most record). On Vancouver Island, Oregon Forestsnail is known from Westholme near Crofton (BC Conservation Data Centre 2013). There are no known records on the Gulf Islands. All records are from elevations less than 360 m asl (above sea level).

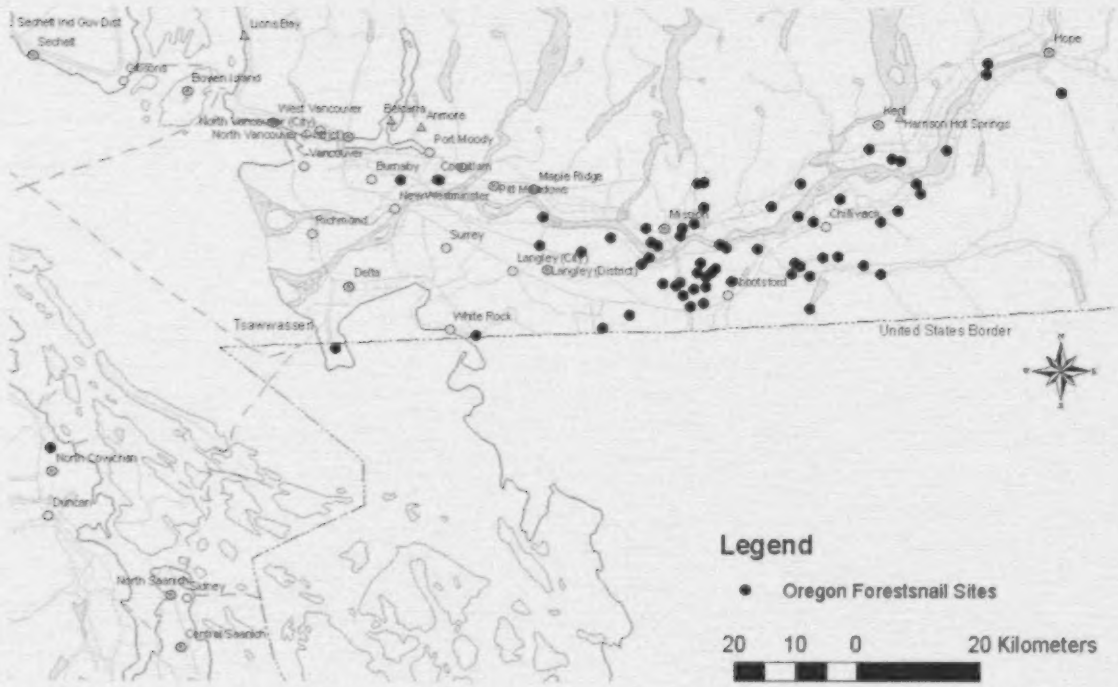

Figure 4. Canadian distribution of Oregon Forestsnail (*Allogona townsendiana*) (see Table 1) (BC Conservation Data Centre 2013).

Oregon Forestsnail records in BC date from 1901 (labelled 'Chilliwack River') (Appendix 1) to April 2012 (various sites, Table 1) (BC Conservation Data Centre 2013). There are 66 sites[1] for Oregon Forestsnail throughout the species' range: 65 within the Lower Fraser Valley and one confirmed site on Vancouver Island at Westholme near Crofton (Table 1) (BC Conservation Data Centre 2013). Many sites were recorded during environmental assessment surveys during the past ten years (Malt pers. comm. 2012; Robbins pers. comm. 2012). The species' range in the Lower Fraser Valley is well defined.

[1] **Site** refers to a record of one or more Oregon Forestsnail individuals from a habitat patch. A site is a "spatial representation of a species or ecological community at a specific area, generally delineates a species population or ecological community stand, and represents the geo-referenced biological feature that is of conservation or management interest. Sites are documented by voucher specimens (where appropriate) or other forms of observations. A single site may be documented by multiple specimens or observations taken from different parts of the same population, or from the same population over multiple years" (Natureserve 2012).

Table 1. Sites occupied and area of occupancy (AO) for Oregon Forestsnail (*Allogona townsendiana*) in BC up to April 2012 (BC Conservation Data Centre 2013). While the ASU Chilliwack site is included, no additional data are provided due to the lack of a data-sharing agreement. A "Yes" for "Fragmentation & Isolation" suggests that the site is not viable for Oregon Forestsnail.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
Silver Creek	1	private ?	1959-07-09	-	0.00	• No information available.
Vedder Crossing	1	private ?	1959-07-17	-	0.00	• No information available.
Clayburn Creek	1	private	2005-07-07	No	0.21	• Approximately 160 acres of potential unsearched high-quality habitat; site has been impacted by urban development.
Hope; Hunter Creek	1	BC crown	2006-07-07	No	78.14	• Snails within mature Bigleaf Maple stands with a relatively open mossy understory with abundant large course woody debris.
Chilliwack, Mount Shannon	2	private ?	2010-01-28	No	9.55	• This area has been heavily developed since the snails were historically collected in 1959. • Most of the recent snails were found near well-used trails. Several dead snails were found on the edge of a bike trail, which appeared to have been recently expanded (e.g., cut vegetation). • The surrounding areas of the mountain contain residential development. • The site is on the northwest-facing side of a mountain that is surrounded by residential and agricultural development. • Habitat is moist, with mature Bigleaf Maple and Stinging Nettle. • Threats: urban development, recreational activity
Poignant Creek	1	private ?	2006-02-27	No	12.50	• The habitat is intact and a small amount of Himalayan Blackberry is growing in the area but is not dominant. • Roads fragment the forest stand to the north, east and south (also recent development to south). However, the habitat is relatively intact and connected to surrounding terrestrial and aquatic resources • Second growth, mixed deciduous/coniferous riparian forest with several mature conifers. The riparian habitat occurs in a ravine surrounding Dianne Brook, which runs through the north end of the survey property. • Threats: urban development
Abbotsford	2	private land	2010-05-19	No	23	• Mature stand of mixed forest; description is that it is in good condition, with significant understory. There is a block of approximately 23 ha of similar forest where the snail was found. • One of the properties is in a block of forest within a fragmented landscape of agriculture and residences, with some riparian corridors; the other property is surrounded by agricultural land. • Threats: possible urban development

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
Chilliwack Mountain	2	private land	2009-08-08	No	12.96	• Approximate 50-year-old Bigleaf Maple stand • The area is a surveyed, posted lot in a low-density residential area • Historical logging has occurred at the site resulting in the removal of conifer trees. • North side is a gravel road 15 - 20 m south of the occurrence, running east-west. There are residential areas toward the eastern end of the road approximately 300m north of the occurrence. The area of occurrence and surrounding areas are not fragmented. • North side: The area is near the base of the slope of the mountain.
Chilliwack, Promontory	3	private ?	2007-06-19	Yes	0.39	• This site is a transition zone between a wet and shady ravine to the north and a dry and sunny field and grassy trail.
Yarrow, south of	1	private ?	2008-05-09	No	4.47	• The area is mature, second-growth mixed-wood forest, occurs on the north side of Vedder Mountain.
Chilliwack, Ryder Creek	3	private ?	2006-03-22	No	33.74	• Both the crown land and private parcels on which the snails were recorded are very unlikely to be developed in the immediate future as they have major geotechnical hazards. • 65 shells and 2 live animals are within 0.3 square kilometres. • The occurrence is within moist, 60-year-old mixed-wood forest with large Bigleaf Maples along steep hillside and small creeks
Tamihi Creek	2	B.C. crown?	2008-05-04	No	4.10	• Tamihi Creek south: primarily mature forest with an approximate age of 70 years; Tamihi Creek north: primarily a 60-year-old stand of deciduous trees • Tamihi Creek south: The occurrence is where the Tamihi Creek emerges from the Chilliwack River.
Cultus Lake, Northwest of; Vedder Mountain	2	B.C. crown, private	2009-06-26	No	19.18	• The area of Vedder Mountain is primarily used for forestry activity. Situated within a Wildlife Habitat Management Area (zone length = 200m) in an approved harvest cutblock (estimated to be less than 100 years old). Selective harvesting is permitted with Crown land, approved cutblock, under timber licence. • Threat: possible logging or road access through Wildlife Habitat Management Area.
Luckakuck Creek, Squiaala Indian Reserve 7	1	Indian Reserve (federal) Squiaala Indian Reserve 7	2007-09-21	No	5.39	• The land is part of Squiaala Indian Reserve 7 and the original proposal included the creation of commercial property within the existing farmland. Present plans for property development are unknown.
Abbotsford, Downes Road	1	private	2005-12-14	No	12.50	• Habitat is on an elevated knoll. Mixed stand dominated by mature Bigleaf Maple and Western Red-cedar with minor component of Douglas-fir, western Western Hemlock and Red Alder. • Threats: possible urban development.
Wharton Creek	1	private ?	2001-06-09	No	3.13	• The area is primarily mature, second-growth forest. • The occurrence is in a regional park. The dominant vegetation species include Bigleaf Maple, The stand age is mature second growth.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
Clayburn, Sahhacum Indian Reserve 1	1	Indian Reserve, Sahhacum Indian Reserve 1	2008-06-12	Yes	0.78	• The western portion of Sahhacum Indian Reserve 1 is undeveloped and covered in natural vegetation. Historically, the western parcel has never been used and there is no existing infrastructure. It is inaccessible and undeveloped. • Sahhacum Indian Reserve 1 is bisected into eastern and western parcels by a transportation corridor occupied by Canadian Pacific Railway, Southern Railway of British Columbia, and the Abbotsford-Mission Highway Number 11. • Good quality wetland and riparian habitats with lowland wetland connected to surrounding terrestrial and aquatic resources within the western parcel. • Threats: in past, development for transportation corridors.
Coquitlam River, west of	1	Colony Farm Metro Vancouver Regional Park - local government	2010-05-20	Yes	5	• Colony Farm Metro Vancouver Regional Park (Figure 10) surrounded by urban development. • Highway 7A and 7B are adjacent to the north and south borders of the park. Colony Farm Road divides the park north to south on the west side. The south end of the park borders the Fraser River. • Habitat is predominantly open fields and wetland complexes, colonized by dense Stinging Nettle, shrubs and tall grass, with only a few scattered deciduous trees. • Threats: in the past, transportation corridors and agricultural field, urban development
Abbotsford, South of Clayburn	1	private	2010-08-22	Yes	0.20	• Watercourse enhancement works have occurred at the site; this has impacted Oregon Forestsnail individuals and habitat at this site. • Found within deciduous riparian corridor along a creek; greenbelt surrounded by suburban residential development. Snail likely occurred throughout similar habitat prior to urban development. • Threats: urban development
Abbotsford, south of Highway 11	1	private	2010-05-20	Yes	0.20	• Residential developments, agricultural and industrial development surround the site. • Threats: urban development.
Nicomen Island	1	private ?	2000-05-23	Yes	2.09	• Disturbed, second-growth forest on Nicomen Island, which is a river-island surrounded by dykes. • Threats: potential flooding may impact population persistence over time.
Mountain Slough	1?	private ?	2007-03-23	Yes	3.13	• This location was formerly a riparian area of Mountain Slough; the general area is predominantly Trembling Aspen and Black Cottonwood • The occurrence is within a recently cleared area of land, about 10-15m from the adjacent water course. • Threats: urban development in the past, and likely future.
Mission, south of Wharton Creek (including Westminster Abbey)	3	private Westminster Abbey; other landowners unknown	2009	Yes	0.73	• A permanent watercourse is present ~5 metres north of the sighting. A shrub wetland exists immediately south of the sighting for ~20-30 metres. • New residential housing exists to the north. • Beyond the riparian corridor to the west the area is fragmented from other adjacent, suitable habitat as a result of existing or planned housing development. • Threats: urban development (in part)
Mission, West Heights	1?	private ?	2007-09-12	Yes	0.20	• Mature deciduous forest vegetation situated along the upslope portion of the south side of the Canadian Pacific Railway right-of-way.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
Sumas Mountain, McKee Peak	2	private ?	2007-05-30	Yes	6.86	• Evidence of future development in area. • McKee Peak is a portion of Sumas Mountain and overall this area is large parcel of natural habitat within the Lower Fraser Valley. Sumas Mountain is experiencing extensive large-scale housing development, both at present and planned for the future.
Willband Creek	1	private ?	2006-07-07	Yes	0.78	• BC Hydro substation to the east and south. Much of the nearby areas are farmed with road access. • In a Red Alder-dominated stand with Stinging Nettle understory surrounded by Himalayan Blackberry.
Tones Creek, south of	1	private ?	2007-09-12	Yes	0.20	• Along the Canadian National Railway right-of-way south of the Fraser River surrounded by Matsqui Main 2 Indian Reserve. • Mature deciduous forest vegetation situated along the upslope portion of the south side of the Canadian National Railway right-of-way.
Abbotsford, Eleanor Avenue	1	private land	2006-11-02	Yes	0.20	• This occurrence is found within mature deciduous-dominated forest habitat within a proposed development study area. • The proposed development study area includes the mature deciduous-dominated forest habitat in which this occurrence is found as well as disturbed/vacant habitat to the south within Lot:3 Sec:14 Twn:16 Plan LMP40494. The survey also extended north to Lonzo Creek. • Threats: urban development.
Abbotsford, Marshall Road	1	private land	2007-02-09	Yes	0.20	• The Upper Ravine and the Ravine Pond area show many signs of human use including tracks, mountain bike jumps, wooden constructed pathways, a fort-like structure, garbage, evidence of campfires and the presence of an old camper top. • The property is surrounded by a large residential development, except for a few small treed areas in between the subdivisions. The plans are for further development if the surrounding area. • Currently, a ravine runs through the property from the northeast to the southwest. The ravine is a natural valley approximately 600 metres long, with slopes of varying heights and steepness. The habitat of the ravine is that of a mixed wood forest. The ravine at this site was partially filled in to allow for road development. • Threats: urban development, recreational use.
Chilliwack Prairie, Central and Patterson Road	3	private ?	2008-08-19	Yes	13.30	• Habitat in a natural state, but selective tree removal was planned to occur in 2008 on the adjacent property. This will degrade the existing habitat, but riparian corridors and smaller tree retention is likely. • Historical logging in the area has removed most conifer trees; residential development is being implemented. Area remains intact, but the property north of the southern detection (7500 Patterson Road) is planned. • Threats: logging, urban development
Hatzic Prairie, Lagace Creek	1	Private	2006-06-11	Yes	0.38	• Possibility of area having been mowed. • Potential habitat for the population is very limited and is not connected to other areas. The two live adults were found in a very isolated patch of forest on the corner of two paved roads and bordered on the other side by a creek • Threats: urban development, vegetation management.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
Pemberton Hills	2	Private	2010-04-17	Yes	10.89	• Site occurs in mixed-wood forest with a stand age of 70 - 80 years. • Strip of natural habitat surrounded by farmland and rural residences. • Both sites are in the Pemberton Hills area within 1 km of each other. • Threats: likely urban development.
Ridgedale, 5km east of	1	Private	2008-06-07	Yes	0.01	• The area has been logged in the past as evident by old stumps • snail was observed along and adjacent to an old logging road. • Deciduous and coniferous trees in the area are now mature. • Popular hiking area, although in some areas there is no disturbance from hikers • The area around the occurrence is in a natural state. • Threats: urban development, possible logging, recreational use.
Straiton, Poignant Creek	1	Private ?	2007-06-27	Yes	1.82	• Ownership of the land is unknown, and extensive development in the area seems to be a major threat. • Straiton Road runs beside the ravine with an approximately 100-metre buffer between the stream and the road. A new residential area was in the process of development on the other side of the ravine • Habitat includes a riparian area that was very moist and in a ravine. • Threats: urban development
Sumas Mountain	1	private ?	2009-04-05	Yes	0.00	• The occurrence is beside a poor trail and may be within an area not subject to development (on Sumas Mountain), but land ownership is unknown.
Tsawwassen	1	private	2008-04-15	Yes	0.73	• Threats include dirt bikes, isolation and insularity of the population. • Occurrence is in a small forest block surrounded by agricultural fields, housing developments and roads (separating it from another forest block to the south in the United States). The area was to be developed into urban housing, but plans were delayed. • Threats: recreational use.
Watt Creek (Cultus Lake)	2	private	2007-05-29	Yes	2.35	• Adjacent to a high-use trail, which is routinely raked, and a tree fort is nearby. • Camp Stillwod is used for summer programs, and often rented to large groups (adults and children) with various buildings, fields and trails to the west and Watt Creek to the east. It is a forested area, previously logged maybe 50 years ago. • Threats: recreational use.
Westholme , NE of Road/Rail junction, near Crofton, Vancouver Island	2	Indian Reserve; federal; perhaps some private	2007	Yes	8.83	• The area is close to a railway track at the edge of a Bigleaf Maple stand that ranges from 40-80 years old. • From aerial photos, the occurrence appears to be surrounded by some suitable habitat, agricultural fields and roads. • The area is within a floodplain in a valley bottom with a high water table. It is close to a railway track at the edge of a mixed-wood forest with Bigleaf Maple that ranges between 40-80 years old.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary[a]
City of Abbotsford, Douglas Taylor Park	1	local government Douglas Taylor Park, City of Abbotsford	2006-03-21	Yes	0.78	• This site is within a 40-year-old mixed-wood forest. • Threats: recreational use.
Aldergrove Regional Park, Aldergrove	1	local government Aldergrove Regional Park Fraser Valley Regional District	2010-05-19	Yes	1.18	• The wetland is off the park trail and is difficult to access. • The park is less than 2 kilometres north of the Canada/US border. Roads parallel the north and west borders of the park. Surrounding land use is primarily agricultural and residential. There are several gravel pits in the vicinity. • The site is within the floodplain of Pepin Creek within a regional park. • This wetland has large woody debris from years of beaver activity. The snail was found on a stump in a small patch of Skunk Cabbage. • Threat: low recreational use
Chester Creek, Mission	1	private	2007-02-16	Yes	0.28	• Undisturbed forested area with creek running through it. • There are over 75 ha of similar undisturbed forest where the snail was found before any roads or clearings. • Forested area with agricultural clearings to the west and south (approximately 225m and 175m respectively). The forested area is more extensive to north and east with the first roads being about 500m away. Generally the landscape is fragmented • Forested area with small creek running through it. Forest floor has large amount of leaf litter and course woody debris. • Threats: possible logging, urban development.
Sperling	1	private	1993-06-08 and 2010	Yes	3.12	• Large forest block; adjacent southwest forest block private property and not protected. • Threats: logging, possible urban development.
Vedder Mountain, Browne Road	1	private	2005-04-05	Yes	0.78	• Area is subject to cattle grazing and trampling of soil. • Habitat: 40-year-old Bigleaf Maple stand with disturbed understory on lower slope of mountain. • Threats: livestock grazing, possible urban development
Village of Kent; Cemetary Hill	1	private land Kent (Village)	2000-05-23	Yes	3.12	• The area is primarily second growth, with some old trees. • Site is on east side of a hill in the Village of Kent.
Trinity Western University, Approximately 3km south of Fort Langley	2	B.C. crown; private Trinity Western University Ecological Study Area	2001-09-08	Yes	0.78	• The area is primarily mature second-growth forest with a large deciduous component. • This occurrence is in the Ecosystem Study Area of Western Trinity University campus, which contains part of the Salmon River and some tributaries. • Threats: possible recreational use, although there is good signage regarding habitat protection and respect for Oregon Forestsnail.
Sumas Mountain Road	1	private ?	2003-06-13	Yes	3.13	• The area is near low-density housing, in a mixed-wood forest with a stand age of approx. 80 years. • The area is by a road on Sumas Mountain near low-density housing. • Threats: possible urban development.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
Sumas Mountain, West Slope	1	private ?	2003-06-13	Yes	3.13	• The area is mixed-wood forest with a stand age of approx. 70 years. • Site is near the base of the West slope of Sumas Mountain. • The stand age is approx. 70 years with moderate leaf litter, light soil and low, coarse woody debris. • Threats: possible urban development.
Sumas Mountain, Cox Road	1	private ?	2006-03-21	Yes	0.78	• Steep hillside with large Bigleaf Maples and Stinging Nettle and Salmonberry understory. • Threats: possible urban development.
Bridal Veil Falls	3	private land; federal (Indian Reserve - Popkum); Bridal Veil Falls Provincial Park; BC crown	2011-07-12	Yes	3.91	• Portion of this site is Bridal Veil Falls Provincial Park that is used by visitors primarily for day use. The park consists of mature, second-growth forest and large patches of Stinging Nettle. A number of snails were recorded adjacent to a recreational vehicle parking area (Figure 8), and were dispersing into mown grass and gravel. • The age of the stand is mature, second growth (< 70 years) with Bigleaf Maple and Western Redcedar • Threats: immediate plans for urban development on non-crown land; trampling and recreational use in the park.
Cheam Wetlands	1	local government Cheam Lake Regional Park Fraser Valley Regional District	2011-05-16	Yes	3.91	• The site is within mature, mixed-wood forest in a regional park. The park has 2 km of trails, some walkways and a picnic area; dogs, watercraft and fishing are prohibited in the park. • Snails recorded from a strip of Stinging Nettle >250 m long and up to 50 m wide along a creek with lots of Oregon Forestsnails, a patch of Stinging Nettle at edge of parking lot lawn, approximately 85 m long and 15 m wide with OFS, scattered Stinging Nettle interspersed with other vegetation in a 1.5 loop around wetlands with Oregon Forestsnail. • Threats: recreation al use.
Chilliwack, Dunville Creek	3	B.C. crown and private	2005-04-08	Yes	2.34	• Ongoing selective logging on lower slope on private land. • Habitat: 70-80-year-old mixed-wood forest stand with Bigleaf Maple (some large) on lower slope of mountain; abundant herbaceous plants in small forest openings. • Threats: logging
Hatzic Lake, 1 km north of	2	Private and B.C. crown	2005-04-13	Yes	1.56	• Habitat: 40-50 year-old mixed-wood forest with Bigleaf Maple on lower slope of mountain; pockets of abundant herbaceous plants, especially near mountain base. • Threats: possible logging.
Hatzic Lake, 4.5 km north of	1	B.C. crown	2005-04-01	Yes	1.56	• Habitat is within a mixed-wood, 60-year-old stand of Bigleaf Maple and alder with dense shrub understory. • Threats: possible logging.
Hope, southwest of	1?	B.C. crown	2006-03-13	Yes	0.78	• Recorded within 50-year-old, moist, mixed-wood forest that slopes steeply toward a creek. • Threats: possible logging.
Hopyard Hill	> 2	private (numerous)	2005-04-07	Yes	3.91	• Primarily young forest, with an approximate stand age of less than 50 years. This site is along a mowed road. • Threats: vegetation management along road.

Site name	Number of land owners	Land ownership information	Most recent observation	Fragmentation & isolation	AO (ha)	General habitat description and threats summary*
South Surrey, Campbell Valley Metro Vancouver Regional Park	2	local government, Metro Vancouver Park	2006-03-06 and 2011 (unknown date)	Yes	1.56	• Snails were found on a south-facing creek bank adjacent to a floodplain. Site is within a 40-50-year-old mixed-wood forest. • Active recreational park with horseback riding and other recreational use.
Vedder Canal Bergman Road	1	private ?	2006-03-08	Yes	0.78	• There is a recreational trail in the area. • Moist, 50-year-old, mixed-wood forest (mostly Red Alder and Black Cottonwood) with patches of Bigleaf Maple along Vedder Canal. • Threats: recreational use
Sumas Mountain, South Slope	5	private	2005-04-12	Yes	0.78	• Site has been (sometime in the past) disturbed by ruminant station and a quarry/gravel pit. • Threats: urban development
D'herbomez Creek	1	private ?	2001-06-09	Yes	0.28	• The site consists of mowed grass along a mature, second-growth forest edge • The age of the stand is mature, second-growth (greater than 100 years). • Threats: vegetation management, urban development.
Herrling Island Road	1?	private ?	2000-05-22	Yes	3.12	• Site located on a grassy surface at the edge of a road along the forest edge.
Nicomen Slough	1	private ?	2000-05-23	Yes	3.12	• The area is primarily disturbed mature, mixed-wood forest near a road at Nicomen Slough.
Wren Creek, Mission	1	private	2012-05 (date not available)	Yes	< 3	• Large private land development that includes the infilling and diversion of a creek with a large population of Oregon Forestsnail.
Brunette Fraser Greenway (Park)	1	local government, Metro Vancouver	2011-05-9	Yes	< 0.5	• Snail recorded from a small patch of Stinging Nettle adjacent to a well-used urban trail. Habitat is not connected to other areas and is highly isolated from other habitat.
Glen Valley	1	local government, Metro Vancouver	2011-05-11	Yes	< 0.5	• Found only at the poplar bar area of the park, three snails found in a patch approximately 80m long x 40m at widest point on trail near parking lot
Neilson Park	1	local government, Fraser Valley Regional District	2011-05-24	Yes	< 0.5	• 150 m long Stinging Nettle strip approximately 10 m wide along base of steep hill at the edge of baseball field full of OFS. This connects to a strip of scattered Stinging Nettle, approximately 250 in length and 40 m wide in the forest east of the baseball field full of OFS
Brae Island	1	private, Metro Vancouver	2011-05-11	Yes	< 0.5	• Stinging Nettle mixed with other vegetation for approximately 800 m along the length of the loop trail, approximately 225 m in width at widest point
Department of National Defence Area Support Unit, Chilliwack	1	Federal	2011 (date unknown)	No	N/A	• Information not available
South Perimetre Road, Surrey	1	B.C. Crown	2011	Yes	N/A	• There are a few sites along this highway expansion project that have Oregon Forestsnail. Some of the snails have been translocated to adjacent habitats, but the original habitat has since been converted to roadways as part of the expansion project.

*(Although not stated, all sites are subject to IUCN-CMP Threats: 7.1 (fire and fire suppression); 8.1 (invasive non-natives, particularly Himalayan Blackberry); 11.1 (Habitat shifting and alteration); 11.2 (droughts); 11.4 (storms and flooding).

Extent of Occurrence and Index of Area of Occupancy

Based on historical and recent records (within the past ten years) the extent of occurrence (EO) is 3,313 km^2, including the single site on Vancouver Island. The current EO was calculated by the COSEWIC Secretariat using a minimum convex polygon within Canada's extent of jurisdiction. The unsuitable habitat of the Strait of Georgia, between the island and mainland, is included in the EO calculation. The EO for the previous status report was approximately 1,863 km^2 (based on map provided in COSEWIC 2002, calculated by the BC-CDC) and would have included only the Fraser Valley but not the Vancouver Island sites (in 2002 this island site was considered historical). New records that increased the EO include Colony Farm Regional Park (Coquitlam), Brunette-Fraser Regional Greenway (Burnaby), Tsawwassen and the confirmed site on Vancouver Island. Each of these four sites is fragmented, isolated and total less than 1 km^2 biological area of occupancy (BC Conservation Data Centre 2013).

The index of area of occupancy (IAO), calculated by the COSEWIC Secretariat, is 300 km^2 (Figure 5) (= 75, 2 km x 2 km grids that cover all sites in Figure 4). The biological area of occupancy calculated by summing the area of all mapped sites is approximately 328 ha (Table 1) (BC Conservation Data Centre 2013).

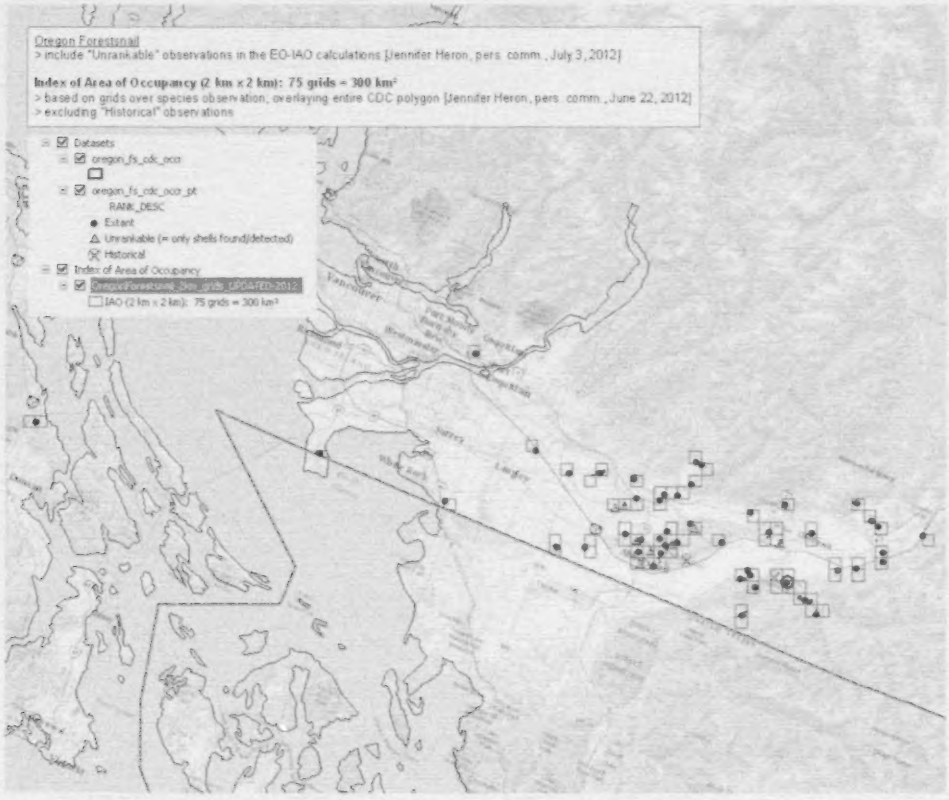
Oregon Forestsnail
> include "Unrankable" observations in the EO-IAO calculations [Jennifer Heron, pers. comm., July 3, 2012]
Index of Area of Occupancy (2 km x 2 km): 75 grids = 300 km²
> based on grids over species observation; overlaying entire CDC polygon [Jennifer Heron, pers. comm., June 22, 2012]
> excluding "Historical" observations
Datasets
oregon_fs_cdc_occ
oregon_fs_cdc_occ_pt
RANK_DESC
Extant
Unrankable (= only shells found/detected)
Historical
Index of Area of Occupancy
IAO (2 km x 2 km): 75 grids = 300 km²
Vancouver

Figure 5. The index of area of occupancy (IAO) for Oregon Forestsnail.

If the three western-most records on the mainland (Burnaby - very small 20 m x 20 m area of Stinging Nettle on a right-of-way pedestrian walkway; Tsawwassen - private land up for development in the next ten years; and White Rock - municipal park; see Figure 5) were extirpated, the EO within Canada's extent of jurisdiction would be reduced to 2,018 km^2 (39%) and IAO would be reduced to 288 km^2 (calculations by COSEWIC Secretariat).

Search Effort

From 2000 – 2011 substantial search effort for Oregon Forestsnail has resulted in additional sites within the species' range in BC (Table 2). Search effort has focused on the edges of the species' range on southeastern Vancouver Island, many southern Gulf Islands and areas throughout the Lower Fraser Valley and Sunshine Coast (Figure 6).

Table 2. Surveys for Oregon Forestsnail (*Allogona townsendiana*) on Vancouver Island, Gulf Islands and Lower Fraser Valley, BC. Note: Search effort time (hours) and search effort distance (km) have often not been measured during surveys.

Survey year	Report citation	Total number of sites surveyed	Number of Lower Mainland or Sunshine Coast sites surveyed	Number of Vancouver Island sites surveyed	Number of Gulf Islands sites surveyed	Search effort time (hours)	Search effort distance (km)
1984	Cameron 1986	38	N/A	N/A	N/A	N/A	N/A
1999 - 2003	Ovaska and Sopuck 2000, 2001, 2002a, 2003a, Ovaska *et al.* 2001	26	2	24	0	N/A	N/A
2000-2001	Ovaska *et al.* 2001	142	38	104	0	196.6	N/A
2002	Ovaska and Sopuck 2002b	3	0	3	0	71.6	5.6
2003	Ovaska and Sopuck 2003b	52	30	22	0	19.25	N/A
2003	Ovaska and Sopuck 2003c, 2004a	43	0	30	13	N/A	N/A
2003 - 2004	Ovaska and Sopuck 2004b	43	4	39	0	131.1	N/A
2005	Ovaska and Sopuck 2005a	47	47	0	0	57.9	N/A
2004 - 2005	Ovaska and Sopuck 2005b	47	47	0	0	57.9	N/A
2006	Ovaska and Sopuck 2006a	26	0	26	0	N/A	N/A
2006	Ovaska and Sopuck 2006b	21	0	21	0	N/A	N/A
2007	Ovaska and Sopuck 2007a	6	0	6	0	N/A	9.2
2007	Ovaska and Sopuck 2007b	6	0	6	0	N/A	
2008	COSEWIC 2010	17	4	13	0		
2008	Ovaska and Sopuck 2008	22	0	22	0	N/A	N/A
2009	Bains *et al.* 2009	10	10	0	0	43	49.6
2008	Ovaska and Sopuck 2009a	6	0	6	0	N/A	N/A
2008	Ovaska and Sopuck 2009b	22	0	22	0	N/A	N/A
2008 - 2009	Ovaska and Sopuck 2009c	22	0	22	0	N/A	N/A
2009	Department of National Defence Formation Environment Natural Resources Program 2009	6	0	6	0	N/A	N/A
2010	Ovaska and Sopuck 2010	10	0	10	0	N/A	7.2
2010	Parkinson and Heron 2010	5	5	0	0	30	34.3

Survey year	Report citation	Total number of sites surveyed	Number of Lower Mainland or Sunshine Coast sites surveyed	Number of Vancouver Island sites surveyed	Number of Gulf Islands sites surveyed	Search effort time (hours)	Search effort distance (km)
2009	Sopuck and Ovaska 2010a	5	0	0	5	N/A	N/A
2010	Sopuck and Ovaska 2010b	1	1	0	0	N/A	N/A
2011	Heron, personal data 2011	39	39	0	0	144	418.9
2009 - 2011	Ovaska *et al.* 2011	5	5	0	0	N/A	N/A
1990 - 2011	Forsyth personal data 2011	450	N/A	N/A	N/A	75.5	N/A
Total: 1984 - 2011		**1083**	**232**	**382**	**18**	**826.85**	**524.8**

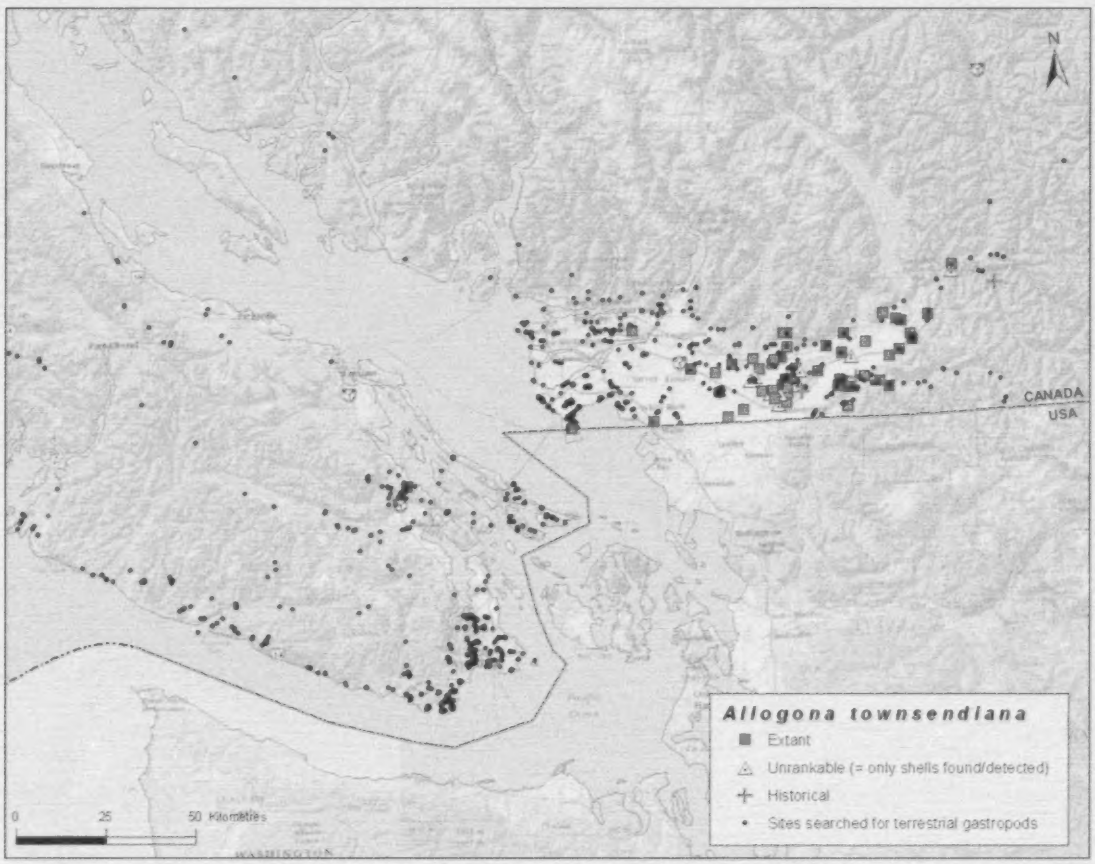

Figure 6. Search effort for terrestrial snails within and adjacent to the known range of the Oregon Forestsnail. The current extant sites and historically occupied sites also are shown. Data from the BC Conservation Data Centre (2013) up to April 2012 as well as Forsyth (unpubl. data up to 2011) are included (map produced by COSEWIC Secretariat).

Surveys for Oregon Forestsnail have primarily been by wandering transects through suitable habitat with the main objective to record snail presence, abundance and habitat information (Table 2). Wandering transects follow no pre-determined grid or fixed route and allow the surveyor to change course depending on habitat suitability. Transect routes are usually tracked using a handheld geographic positioning system (GPS) unit to also quantify search effort. This methodology has not allowed for population size or trend evaluations, mostly because surveys have been to assess environmental values prior to development and sites are not revisited.

The presence of Oregon Forestsnail shells is considered evidence of recent live individuals at a site. Oregon Forestsnail is typically reported incidentally during other wildlife surveys and not during the ideal survey window (e.g., snails may be hibernating or aestivating). Pearce (2008) found clearly identifiable terrestrial snail shells after 4 to 7 years exposure in forests of Delaware and northern Michigan but cautions that decomposition rates varied among species but not between the two habitats he tested.

Since 2000, gastropod surveys within the range of Oregon Forestsnail amount to a minimum of 1083 sites surveyed (232 sites in the Lower Fraser Valley; 382 sites on Vancouver Island, 18 sites on the southern Gulf Islands) (Figure 6). From 2009 - 2011, there is a minimum of 827 hours and 525 km of search effort for Oregon Forestsnail, including surveys completed as part of the updated status report preparation. The actual search effort since 2000 (hours and kilometres) is much higher because many surveyors did not record this information (Table 2). For this reason, the number of sites surveyed is the best indication of search effort.

Oregon Forestsnail is often recorded as an incidental observation and in the past ten years, biologists, naturalists, and members of the public have voluntarily submitted new observations to the BC Conservation Data Centre (2013), which has increased the knowledge on distribution and habitat association. Of particular importance, professional biologists working on environmental assessments often contribute null data (e.g., search effort for Oregon Forestsnail with no specimens found) (Ferguson pers. comm. 2011; Bianchini pers. comm. 2012; Durand pers. comm. 2012; Knopp pers. comm. 2012; Malt pers. comm. 2012). The null data are not possible to quantify yet the contribution to overall search effort is notable.

The following conservancy groups working on various Gulf Islands have not recorded Oregon Forestsnail during surveys: Salt Spring Island (Annschild pers. comm. 2011), Denman Island (Fyson pers. comm. 2012), Hornby Island (Law pers. comm. 2011), Mayne Island (Dunn pers. comm. 2011) and Galiano Island (Crowe pers. comm. 2011).

HABITAT

Habitat Requirements

Information used to describe Oregon Forestsnail habitat in BC includes the collective efforts of occurrence records in the BC Conservation Data Centre (2013) and the provincial recovery plan for Oregon Forestsnail (Oregon Forestsnail Recovery Team 2012), which is the source of information for much of what follows, unless otherwise indicated.

Oregon Forestsnail habitat is low elevation (30 – 360 m asl), deciduous and mixed-wood broadleaf forests with multi-structured vegetative microhabitat and sustained high moisture and relative humidity. High-quality habitat includes forests with high site index (forest growth productivity) including riparian areas, ravines, gullies and depressions containing both permanent and ephemeral watercourses; the wooded edges of streams, marshes, seasonally flooded and wet lowland areas; forest interfaces, and edge habitats where moisture is retained (Waldock 2002).

Forest overstory composition includes deciduous and mixed tree species, 20 to greater than 80 years old, and dominant overstory composition greater than 40%. Overstory composition includes large Bigleaf Maple (*Acer macrophyllum*), Black Cottonwood (*Populus trichocarpa*) and scattered Western Redcedar (*Thuja plicata*). Additional trees present include Paper Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), Red Alder (*Alnus rubra*) and Grand Fir (*Abies grandis*).

Dominant shrub species composition is typically dense shrub vegetation that functions to minimize moisture and evaporative loss from this vegetative layer. Native shrub species composition includes a suite of the following: Devil's Club *(Oplopanax horridus*), Elderberry (*Sambucus racemosa*), False Azalea (*Menziesia ferruginea*), Beaked Hazelnut (*Corylus cornuta*), Indian Plum *(Oemleria cerasiformis*), Ocean Spray (*Holodiscus discolor*), Red-osier Dogwood (*Cornus stolonifera*), rose (*Rosa* sp.), Salmonberry (*Rubus spectabilis*), Salal (*Gaultheria shallon*), Saskatoon (*Amelanchier alnifolia*), Common Snowberry (*Symphoricarpos albus*), Thimbleberry (*Rubus parviflorus*) and Vine Maple (*Acer circinatum*).

Herbaceous plant composition consists of live and senescent vegetation, which provides food and cover during all life stages. Snails are often found at the base of large vegetation clumps or plants (e.g., leaf litter at the base of trees, shrubs and ferns). Herbaceous composition includes: bedstraw (*Galium* sp.), Bleeding Heart (*Dicentra formosa*), buttercup (*Ranunculus* sp.), Cow Parsnip (*Heracleum maxiumum*), Enchanter's Nightshade (*Circaea alpina*), False Lily-of-valley (*Maianthemum dilatatum*), Foam Flower (*Tiarella trifoliata*), Fringecup (*Tellima grandiflora*), Cooley's Hedge Nettle (*Stachys chamissonis var. cooleyae*), horsetail (*Equisetum* sp.), miner's lettuce (*Claytonia* sp.), Pathfinder (*Adenocaulon bicolor*), Skunk Cabbage (*Lysichiton americanum*), starflower (*Trientalis* spp.), Stinging Nettle, thistle (*Cirsium* sp.), Tiger Lily (*Lilium columbianum*), Western Trillium (*Trillium ovatum var. ovatum*), Clasping-leaved Twisted Stalk (*Streptopus* spp.), Vanilla Leaf (*Achlys triphylla*) and waterleaf (*Hydrophyllum sp.*) and Creeping Buttercup (*Ranunculus repens*). Ferns commonly recorded within Oregon Forestsnail habitat include Bracken Fern (*Pteridium aquilinum*), Ladyfern (*Athyrium filix-femina*), Northern Maidenhair Fern (*Adiantum aleuticum*) and Western Sword Fern (*Polystichum munitum*).

Most habitats of Oregon Forestsnail contain patches of Stinging Nettle (Figures 7, 8, 9, 10). Stinging Nettle appears to have high importance to Oregon Forestsnail populations especially for mating and egg-laying (Waldock 2002; Steensma *et al.* 2009). The consumption of Stinging Nettle is likely needed for healthy shell growth, as the plant contains high levels of calcium and other essential minerals needed to maintain shell durability. Stinging Nettle is also important to other land snails (Iglesias and Castillejo 1998). Waldock (2002) examined the association of Oregon Forestsnail with Stinging Nettle in detail at TWU-ESA (Trinity Western University Ecological Study Area) in Langley, and found a positive correlation between the abundance of the snails and Stinging Nettle. The presence of Stinging Nettle indicates moist, rich soils with high amounts of nitrogen and phosphorus (Pojar and MacKinnon 1994).

Figure 7. Open and forested habitat at Campbell Valley Regional Park, Langley. Mixed-wood forest with Bigleaf Maple and patches of Stinging Nettle represent potential Oregon Forestsnail habitat, June 1, 2010. Photo Laura Parkinson.

Figure 8. Oregon Forestsnail (*Allogona townsendiana*) habitat. Aldergrove Lake Regional Park, Abbotsford. A patch of Stinging Nettle where Oregon Forestsnail were observed, May 19, 2010. Photo Laura Parkinson.

Figure 9. Oregon Forestsnail (*Allogona townsendiana*) habitat at Bridal Veil Falls Provincial Park, July 9, 2011. Note dense patch of Stinging Nettle (*Urtica dioica*) adjacent to a road right-of-way and parking area for recreational vehicles (partially shown). Photo by Jennifer Heron.

Figure 10. Oregon Forestsnail (*Allogona townsendiana*) habitat at Colony Farm Regional Park, June 11, 2010. The trail edges and habitat beyond have dense Stinging Nettle (*Urtica dioica*). Photo by Jennifer Heron.

Soil composition at Oregon Forestsnail sites includes rich, mesic and soft, productive, moist, well-developed mull-type[2] litter layer soils and is an important habitat requirement at all life stages (Cameron 1986; Steensma *et al.* 2009). Litter depth (leaves and needles) is typically 5 – 10 cm (Durand 2006) and often greater than 15 cm. This deep litter layer provides shelter, hibernation and aestivation sites (Steensma *et al.* 2009; BC Conservation Data Centre 2013). Soil pH was 6.4 – 6.9 from three sites in Langley (Steensma *et al.* 2009) while soil temperature was 9.9 – 13°C.

Oregon Forestsnail is recorded from habitats with abundant coarse woody debris at various stages of decay. Size ranges from large-diameter pieces to a forest floor composed of thin, compact leaf litter. Coarse woody debris is an important habitat attribute for Oregon Forestsnail activity: mating, nesting, aestivation, hibernation and egg laying (Steensma *et al.* 2009) and offers protection against daily or seasonal variations in temperature and water availability (as summarized in Prior 1985; Steensma *et al.* 2009). Decaying logs retain moisture and allow for the growth of a thick and healthy moss layer, both of which provide essential shelter during warm and dry weather conditions. It is important for Oregon Forestsnail to have a suitable resting site where moisture can be absorbed through the foot; contact re-hydration is crucial for survival of gastropods (Prior 1985). Large diameter, damp rotten logs provide sites for aggregating and mating (Steensma *et al.* 2009; BC Conservation Data Centre 2013). Oregon Forestsnail has been occasionally observed ovipositing within well-decayed wood (Steensma *et al.* 2009; BC Conservation Data Centre 2013) but also build nests in soil and moss (see Life Cycle and Reproduction). Soils soft enough for digging but firm enough for the nesting chamber to hold its shape is an important habitat requirement.

One study at TWU-ESA recorded Oregon Forestsnail mating pairs requiring humidity greater than 76% with optimum humidity 81 – 100%. These results suggested this environmental factor may have more of an influence over mating activity than air temperature (ranged from 7.1 – 17.0°C) (Steensma *et al.* 2009). Soil moisture measured at three of seven Oregon Forestsnail mating sites at TWU-ESA was 30 – 37% (Steensma *et al.* 2009).

Habitat Trends

The Canadian range of Oregon Forestsnail coincides with the most densely populated and highly fragmented region of BC. The Lower Fraser Valley and southern Vancouver Island regions have had extensive habitat loss, fragmentation, and modification over the past 100 years. Such modifications include extensive logging of forested hillsides, valley bottoms and riparian areas before the 1950s; large-scale changes to watercourses and reduction of wetlands such as the draining of a large lake (Sumas Lake in the Fraser Valley) in the 1920s to reclaim land for agriculture and flood control; diversion and channelling of rivers and creeks; and extensive urban and rural settlement (Sleigh 1999).

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[2] Rich moist soil composed of a thick humus organic layer, decomposing deciduous leaf litter, some mineral soil content and the presence of invertebrate soil fauna.

Habitat trends include the cumulative and widespread loss of habitat due to land conversion; the cumulative spread of invasive species and resultant changes to ecosystem composition, structure and function, including soil structure and biotic species composition; as well as the gradual impacts from climate change. Each of these factors is discussed further in **THREATS AND LIMITING FACTORS**.

Lower Fraser Valley habitat trends

Oregon Forestsnail inhabits riparian lowland forests and areas next to wetlands, some of which may be seasonally flooded (see **Habitat Requirements**). Development throughout the Lower Fraser Valley from the 1860s to present has resulted in a reduction of wetland cover from approximately 10% to less than 1.5% (as of 1996) (Boyle *et al.* 1997 as cited in BC Ministry of Water, Land and Air Protection 2002). These wetland areas include lowland swampy and marshy land that would have been seasonally flooded (Boyle *et al.* 1997 as cited in BC Ministry of Water, Land and Air Protection 2002). If the loss of wetlands is used as a surrogate for loss of natural Oregon Forestsnail habitat, it is assumed there has been an 85% decline of wetland habitat and riparian areas since European settlement began. Most recently, between 1999 and 2009, 306 ha of wetland were lost in the lowlands of the Fraser Valley (Buffet *et al.* 2011).

Oregon Forestsnail habitat also includes open riparian habitats adjacent to streams and more permanent wetlands (see **Habitat Requirements**). Since European settlement, there has been extensive alteration to stream flow in the Lower Fraser Valley. As a result, approximately 15% of streams that once existed in the Lower Fraser Valley no longer exist and 71% are considered threatened or endangered (Fraser River Action Plan 1998 as cited in BC Ministry of Water, Land and Air Protection 2002). If the loss of streams is used as a surrogate for loss of natural Oregon Forestsnail habitat, it is assumed there has been a 15% decline in streamside potential habitat since European settlement began.

Over the past ten years there has been exponential urban and agricultural land development within the Lower Fraser Valley. The human population within the Lower Fraser Valley has increased 10.4% between 2001 and 2007 (last census date) to approximately 2.5 million people. This increase is one of the highest human population growth rates on the continent (Ipp 2007). At a minimum, there have been 17 urban housing developments (Greater Vancouver Real Estate 2011) within the municipalities of Mission, Abbotsford, and Chilliwack that may have impacted Oregon Forestsnail habitat or populations (as observed through satellite imagery). These urban developments include large-scale new communities that include new infrastructure, such as schools and roads. Most of this development has been within privately owned natural land within the Sumas Mountain, Vedder Mountain and Whatcom areas of the Lower Fraser Valley.

Many of the remaining natural ravines in the Lower Fraser Valley are surrounded by urban development (existing or planned) and as such there is an increase in proposed development projects that involve infilling, diverting or channelling existing natural water courses to accommodate access among urban developments. Such developments require approvals under the BC *Water Act*. In the past five years, there have been at least eight development project sites (and *Water Act* approvals) where Oregon Forestsnail has been recorded and where at least a portion of the species' habitat was converted to roads, or other infrastructure (Malt pers. comm. 2012; Robbins pers. comm. 2012). During at least three projects, there has been salvage of Oregon Forestsnail adults (Malt pers. comm. 2012; Robbins pers. comm. 2012). Much Oregon Forestsnail habitat within the Lower Fraser Valley under potential urban development pressure may not require *Water Act* approvals because there are no requested changes to a watercourse thus triggering this legislative requirement.

Industrial and business park expansion plans are published for some municipalities within the Lower Fraser Valley, such as the City in the Country Plan specific to the City of Abbotsford. This plan projects the need for "1,300 acres of employment-generating industrial and business park lands over the next 20 years" with "future residential development accommodated through hillside development...not accommodated by expansion into the Agricultural Land Reserve" (City of Abbotsford 2004).

While the overall amount of habitat loss that has occurred in the past and is projected to occur into the future over the entire range of Oregon Forestsnail is untallied, a geographic information system (GIS) mapping exercise was done (Appendix 2). The exercise consisted of overlaying known Oregon Forestsnail occurrence records available to the BC Conservation Data Centre (2013) with projected urban growth boundary layers for the Fraser Valley Regional District. Each municipality has separate bylaws that require development proposals to consider environmental values such as species at risk (see **Habitat Protection and Ownership**). Abbotsford has some of the most stringent environmental bylaws in the province and requires proponents to collect data on species at risk under specific Wildlife Assessment Report Guidelines (City of Abbotsford 2010). The best data on Oregon Forestsnail distribution as well as GIS habitat overlays is available for the Abbotsford region, which is in the centre of the Canadian range (Figure 4). The conclusion of the mapping exercise was that all areas within the urban growth boundary are slated for future land conversion and development. This development will eliminate most large contiguous Oregon Forestsnail habitats, and the small pieces of habitat that remain as part of municipal set-aside requirements, riparian corridors, or compensation are likely to be sinks with snail populations declining to or close to zero in the short term (< 10 years). While it is currently not possible, given the available data, to quantify the effects of this urban development on reductions in EO, IAO, number of populations, and number of mature individual Oregon Forestsnail, the outlook is not good.

Habitat trends within southeastern Vancouver Island and Gulf Islands

Habitat trends within southeastern Vancouver Island follow a similar decline to those in the Lower Fraser Valley. Agricultural and urban development, logging and infilling have impacted riparian areas, broadleaf deciduous forests, wetland habitats and seasonal flooding regimes and thus have likely led to an overall decline in the natural habitat available for Oregon Forestsnail. There is little information on overall low elevation, deciduous broadleaf forests and wetland or riparian habitat loss within southern Vancouver Island.

Sensitive ecosystem mapping inventory for east Vancouver Island and Gulf Islands completed from 1993 – 1997 showed approximately 8,800 ha (11%) of nine sensitive ecosystem types (in the study) in the early 1990s had been disturbed by 2002. Potential Oregon Forestsnail habitat within this study area lost/disturbed includes riparian (4.6%), woodland (2.6%) and wetland (2.0%) ecosystems (Kirkby and Cake 2004).

BIOLOGY

Life Cycle and Reproduction

A recent Oregon Forestsnail study assessed population size, reproductive timing and habitats, seasonal behaviours and juvenile activity over a four-year period at TWU-ESA in Langley (Steensma *et al.* 2009) and provides most of the information summarized below.

Seasonal patterns of Oregon Forestsnail activity was assessed by tracking 15 snails for two years by harmonic detection finder (see Steensma *et al.* 2009). In general, mating begins in February and lasts through early June. As the warmer and drier summer months approach, snails seek shelter deep within litter, under logs or the bark of coarse woody debris, or in similar shelter places within the deciduous forests where they predominantly live (see **Habitat Requirements**). This aestivation period lasts a few months and in mid- to late September snails will become active again for the wet fall months. Once the first frosts occur, Oregon Forestsnail enters hibernation until the following spring. Winter hibernation begins sometime between late October and lasts until late February, when temperatures are below 10.6°C (Steensma *et al.* 2009).

During hibernation Oregon Forestsnails bury themselves 2 – 7 cm within leaf litter, moss, soil or other forms of cover, form an epiphragm, and orient themselves with the aperture of the shell upwards (Steensma *et al.* 2009). Adult snails are not likely to move although five tracked adults moved (average distance 14 cm) during the hibernation period, and may have fed during this time. Juveniles have not been observed during hibernation months (Steensma *et al.* 2009; BC Conservation Data Centre 2013).

This species is most active during the wet spring months when mating takes place. Oregon Forestsnail is hermaphroditic; although self-fertilization is unknown it could decrease reproductive success as has been seen in other gastropods (Forsyth 2004). Oregon Forestsnail mating pairs (Figure 11) have been observed at three sites in BC. Snails are active from early February with the peak mating period from early March through early May (Steensma *et al.* 2009), and as late as June (Kus 2005). Mating has been observed to occur directly on or within proximity (< 3 m) of coarse woody debris (e.g., logs); Stinging Nettle also grew less than 1 m from mating pairs (Steensma *et al.* 2009). Snails are more active during mating season, move farther and are more likely to be communal; these behaviours increase vulnerability.

Figure 11. Mating individuals of Oregon Forestsnail (*Allogona townsendiana*) as observed at Trinity Western University Ecological Study area (Figure 2B reproduced with permission from Steensma *et al.* 2009).

Oregon Forestsnail nesting and egg laying has been documented at three different sites in BC (Cemetery Hill, Nicomen Slough and TWU-ESA, see Table 1) (Steensma *et al.* 2009); Ovaska *et al.* (2001) also have a number of observations for other sites. Steensma *et al.* (2009) observed snails nesting from April 20 – June 20, peaking in mid-May. Oviposition occurs after adult snails dig or burrow into new or existing nesting holes. Fifty-three nests were surveyed over a two-year period with adult snails digging a 6 – 10 cm flask-shaped hole, the equivalent of their body size, with their foot. Most snails dug nests although snails were also observed nesting within pre-existing depressions in soil, moss and under coarse woody debris. Snails have also been observed laying eggs at the base of vegetation, such as Creeping Buttercup, and occasionally within the same burrow as another snail.

Juvenile snails hatched approximately 8 – 9 weeks after oviposition, with direct observation of hatching observed at two nests following 63 and 64 days of incubation (Steensma *et al.* 2009). Asynchronous hatching was observed although this is likely a factor of environmental variability and has also been observed in other land snails (Forsyth 2004). Juveniles began dispersing from the nest site within hours of hatching, found mostly on mixed soil, leaf litter or soil only. Following hatching, snail activity included climbing less than one metre on tall vegetation within close proximity to the nest although no relationship was found between climbing behaviour and temperature or humidity. Vegetation favoured by juvenile Oregon Forestsnail individuals included Stinging Nettle, Reed Canary Grass *(Phalaris arundinacea*), Indian Plum, and Himalayan Balsam (*Impatiens glandulifera*). Older juveniles (not hatchlings) were observed feeding on Stinging Nettle (Steensma *et al.* 2009).

Adults likely reach reproductive maturity by 2 years and have a life span of at least 5 (Steensma *et al.* 2009) to 8 years (COSEWIC 2002) although 5-8 years is likely an underestimation. Based on the probable age at first reproduction and life span, generation time is approximately 4 to 6 years; the average generation time estimate is 5 years.

Physiology and Adaptability

There is no information on the physiology or adaptability of Oregon Forestsnail in BC. The snail's association with Stinging Nettle (see **Habitat Requirements** and **Interspecific Interactions**) is not considered host plant specificity.

Dispersal and Migration

Oregon Forestsnail is sedentary and has a patchy distribution throughout the northern part of its global range. Oregon Forestsnail is not seasonally migratory nor does the species move from different habitat types during various stages of its life history although minor seasonal movements could occur between foraging, egg-laying, and hibernation areas (see below).

Studies of 21 tracked adult Oregon Forestsnail at TWU-ESA since 2005 showed, minimum convex polygon home ranges from 12.5 to 331.4 m^2 (Lilley pers. comm. 2011; Steensma pers. comm. 2011). The home ranges were frequently long and narrow and most of the snails' movements appeared to be in one direction (Lilley pers. comm. 2011; Steensma pers. comm. 2011). This is consistent with other studies that show snails follow logs and other forms of woody debris, as well as their own mucus trails (Prior 1985).

Edworthy *et al.* (2012) recorded average adult Oregon Forestsnail movement of 2.5 m/month; snails generally remained in a core area of less than 15 m^2. The maximum daily dispersal was 4.5 m and the maximum displacement over 3 years was 32.2 m. The urban/rural environment likely presents inhospitable and impassable barriers, including roads, yards and agricultural fields. The home range of a single individual ranged from 18.4 m^2 to 404.4 m^2 and often overlapped both forest and meadow habitat. No difference in home range size was found between snails that used primarily forest versus those that used primarily edge or meadow habitat, likely due to the presence of Stinging Nettle in edge and meadows.

Gastropods can use homing behaviour near their home site, foraging and returning to the same site. This homing behaviour ensures their return to suitable shelter and minimizes dehydration (Rollo and Wellington 1981; Prior 1985) and could indicate territorial defence (Rollo and Wellington 1981). Oregon Forestsnails leave a dilute mucus trail during movements and likely exhibit homing behaviour by following their own mucus trails or the trails of other gastropods.

Passive dispersal or transport aided by a carrier (e.g., mammals, birds) is unlikely. There is a possibility Oregon Forestsnail eggs, juveniles or adults could be transported during flooding events on pieces of large woody debris with a large, intact moss or litter layer.

Interspecific Interactions

Oregon Forestsnail is often observed consuming and/or found in close association with Stinging Nettle (BC Conservation Data Centre 2013). There is no direct research that links the nutritive values of Stinging Nettle with Oregon Forestsnail, yet research on other land snails shows a significant correlation. Home ranges of Oregon Forestsnail were significantly smaller in the presence of Stinging Nettle (Edworthy *et al.* 2012). Field observations of the European land snail (*Cornu aspersum*) showed Stinging Nettle is significantly correlated with snail presence, partially explained by higher protein, ash and calcium contents in the plant (Iglesias and Castillejo 1998).

Oregon Forestsnail are likely eaten by small mammals, birds, and other molluscs. The native snail Robust Lancetooth (*Haplotrema vancouverense*) has been observed feeding on both eggs and juveniles of Oregon Forestsnail in at least four instances (Steensma *et al.* 2009). Studies at TWU-ESA noted Oregon Forestsnail juvenile hatchlings (and adults) shared their habitat with other land snails, including Robust Lancetooth, Pacific Sideband (*Monadenia fidelis*) (native), Grovesnail (*Cepea nemoralis*) (introduced), Pygmy Oregonian (*Cryptomastix devia*) (native), and Northwest Hesperian (*Vespericola columbianus*) (native), as well as with various slugs including non-native *Arion* species.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

The most studied population of Oregon Forestsnail in BC is within TWU-ESA, where snail movement and life history patterns were initially studied periodically over six years beginning in 2000 (Steensma *et al.* 2009); these studies are continuing (Steensma pers. comm. 2012). Data were collected during spring months, when climate conditions are optimal and snails are most active (e.g., during breeding season). Four 24 m^2 study sites were assessed for snail population densities using the Jolly-Seber mark and recapture technique (Krebs 1989). Sites were searched for individuals for 30 minutes each on five consecutive days (June 8 – 12, 2004), at exactly the same time each day. Population estimates were made using the computer program JOLLY (USGS Patuxent Wildlife Research Center, Laurel, MD, USA) (Pollock *et al.* 1990) with the assumptions: all snails have equal survivability and equal catchability, processing time is brief, marked snails are immediately released and marks are easily seen.

The population of Oregon Forestsnail at one of the training areas managed by the Department of National Defence (DND) at Area Support Unit (ASU) Chilliwack also was studied (Hawkes and Gatten 2011) to determine the area of occupancy, distribution and estimate population size throughout the federal property. Data were gathered in the fall, which is not considered ideal timing (e.g., not breeding season); however, snails are known to be active and visible during the wet fall months. A total of 32 plots, each 25 m^2 (5 m x 5 m plots = total 800 m^2), was randomly selected within habitat deemed likely to have Oregon Forestsnail. Habitat was chosen based on aerial photograph interpretation of sites for habitat elements (see **Habitat Requirements**). Plots were searched for 20-minute intervals; searches under leaf litter and coarse woody debris allowed discovery of aestivating snails. Snail populations were estimated by summing gastropods recorded per plot and calculating density (snails/m^2) (Hawkes and Gatten 2011).

Abundance

There are insufficient data to provide an accurate estimate of Oregon Forestsnail abundance across the entire range in BC. Data on populations at each site has minimal information on population size or trend. Oregon Forestsnail sites mapped by the BC Conservation Data Centre (2013) and data gathered during the preparation of this status report provide some information on snail abundance. Oregon Forestsnail site abundance ranges from one individual (at least 17 sites) to counts greater than 20 snails (9 sites). The largest number of observations at one time is 670 individuals at Colony Farm Regional Park (Figure 10) (Parkinson and Heron 2010).

Two studies are available on population estimates. Steensma *et al.*'s (2009) population estimates among the four study areas within the TWU-ESA ranged from seven to 47 snails in their four 24-m^2 sampling sites with an overall mean population density of 1.0 snail/m^2. At the other population estimation site (Chilliwack), the estimated density of Oregon Forestsnail was highest in riparian habitats (0.14 snail/m^2) and second-growth mixed deciduous forests (0.13 snail/m^2) (Hawkes and Gatten 2011). These data from Chilliwack were not gathered in the breeding season (ideal time) but were collected in the wet fall when snails are known to be active and visible. Until a survey is repeated in spring mating season, the Chilliwack results should be treated with uncertainty.

These minimum and maximum density estimates were multiplied by the total biological area (m^2) of mapped occurrences (~ 3,278,300 m^2) (see Table 1; BC Conservation Data Centre 2013) to derive a crude population estimation range. The Canadian population for Oregon Forestsnail is therefore estimated to contain from 426,000 to 3.3 million individuals.

Fluctuations and Trends

There is minimal information on fluctuations and trends for Oregon Forestsnail populations. While the 1903 historical Vancouver Island site was confirmed in 2003 and 2009, it is suspected that populations have been or will be lost from the 17 urban housing developments that have already occurred in the Lower Fraser Valley (see **Habitat Trends**) and the many others that are planned within the current urban growth boundaries.

Severe Fragmentation

The persistence of Oregon Forestsnail populations in the landscape is dependent on interconnected and suitable habitat patches and dispersal. Urban and agricultural development, combined with natural succession, fire suppression and infilling/draining of lowland wetland riparian habitats (see **THREATS AND LIMITING FACTORS**) has likely led to the isolation of populations and subsequent inability of snails to disperse and recolonize habitat patches. Eventually, cumulative threats combined with limiting factors likely led to extirpation within some sites. What is certain is that since the initial status report (COSEWIC 2002) there has been substantial loss of Oregon Forestsnail habitat and individuals from urban development (see **THREATS AND LIMITING FACTORS**).

It is difficult to assess the effectiveness of Oregon Forestsnail dispersal abilities from one patch of suitable habitat to the next. Distances between known sites can be large (> 10 km) (Figure 4), although if there is sufficient habitat it is likely the snail could disperse, over time, through these areas as must have happened in the past to give the historical Canadian distribution of the species. Snails typically have small home ranges, although Oregon Forestsnail may colonize new habitats including artificially created ones (e.g., ditches, fallow flooded areas) over time if the habitat is not continually disturbed or barriers to movement are not prolonged or permanent.

Using expert opinion, each of the 66 known sites was scored (yes/no) for fragmentation and isolation depending on its size and siting i.e., is it surrounded by city or highway or pending development or within a protected area (Table 1). Fifty-two of the 66 known sites (78.8%) were assessed as fragmented and isolated. At least 50 sites are less than 5 ha and/or are subject to urban development within the next 10 years (see **THREATS AND LIMITING FACTORS**). These sites are isolated by distances of more than 1 km of unsuitable habitat as a result of past land development (since 2002) and most likely will not be able to maintain a viable snail population in the future. Examined another way, 50 of the 75 occupied 2 km x 2 km grid squares (66.7%) also are not viable. While the IUCN (2011) definition for severely fragmented does not contain a timeline in which to assess the viability of a subpopulation, if the average generation time is 5 years, three generations will occur by 2028. Some of the IUCN (2011) quantitative criteria for assigning status, which COSEWIC uses as guidelines, use 10 years or 3 generations, whichever is longer (up to a maximum of 100 years) as a time line; however, 100 years is also used in the quantitative analysis criterion E.

The proportion of the known area of occupancy that is fragmented and isolated equates to 108 ha of the 328 ha (33%) of the biological area of occupancy of mapped sites. Calculated this way, the situation does not strictly satisfy the IUCN definition for severe fragmentation when data are available: most (> 50%) of the total area of occupancy is in habitat patches that a) are smaller than required to support a viable population and b) the habitat patches are separated by large distance. But, examined other ways, the nearly 80% of the total number of known sites and 67% of the occupied 2 km x 2 km grid squares being considered too small and isolated to maintain viable populations does meet the spirit and intent of severe fragmentation. One must also not forget that these current, remnant fragments are indicative of larger pieces of habitat that once existed.

Rescue Effect

There is similar Oregon Forestsnail habitat south of the international border and thus populations likely occur within these areas. The separation distances or habitat connectivity between US and Canadian sites is unknown. Therefore the possibility of rescue is difficult to assess but likely is minimal even given suitable, connected cross-border habitat – snails have limited dispersal capability. Washington State has not been tracking the conservation status of Oregon Forestsnail nor is there recent survey information on the species (Potter pers. comm. 2011; Stellini pers. comm. 2011; Thomas pers. comm. 2011).

THREATS AND LIMITING FACTORS

Threats to Oregon Forestsnail

The International Union for Conservation of Nature-Conservation Measures Partnership (2006) (IUCN-CMP) threats calculator was used to classify and list threats to Oregon Forestsnail (Salafsky *et al.* 2008; Master *et al.* 2009). This exercise was completed by the Oregon Forestsnail Recovery Team, chaired by the status report writer; Molluscs SSC (Species Specialist Sub-committee) co-chairs and an expert on applying the threats calculator attended a subsequent teleconference (6 June 2012) where initial results were re-evaluated. The overall Threat Impact for Oregon Forestsnail is Very High (Table 3). Major level 1 threats (highest to lowest impact) include Threat #1. Residential and commercial development; Threat #4. Transportation and service corridors; Threat # 8. Invasive and other problematic species and genes; and Threat #6. Human intrusions and disturbance. Threats that are applicable to Oregon Forestsnail are further discussed below under the IUCN-CMP level 1 headings, from highest to lowest impact.

Table 3. Threat classification table for Oregon Forestsnail. The threat classification below is based on the IUCN-CMP (International Union for Conservation of Nature–Conservation Measures Partnership) unified threats classification system and is consistent with methods used by COSEWIC, BC Conservation Data Centre and BC Conservation Framework (BC Ministry of Environment 2011a). For a detailed description of the threat classification system, see the Conservation Measures Partnership website (CMP 2010). For information on how the values are assigned, see Master *et al.* (2009) and table footnotes for details. Threats for Oregon Forestsnail were assessed across the species' geographic range in Canada (Table 1).

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
1	Residential & commercial development	High	Large (31-70%)	Extreme (71-100%)	High
1.1	Housing & urban areas	High	Large (31-70%)	Extreme (71-100%)	High
1.2	Commercial & industrial areas	High	Large (31-70%)	Extreme (71-100%)	High
1.3	Tourism & recreation areas	Low	Small (1-10%)	Slight (1-10%)	High
2	Agriculture & aquaculture	Low	Restricted (11-30%)	Moderate (11-30%)	High
2.1	Annual & perennial non-timber crops	Low	Restricted (11-30%)	Moderate (11-30%)	High
2.2	Wood & pulp plantations	Negligible	Negligible (<1%)	Slight (1-10%)	Moderate
2.3	Livestock farming & ranching	Low	Small (1-10%)	Slight (1-10%)	High
3	Energy production & mining	Low	Small (1-10%)	Extreme (71-100%)	Moderate
3.2	Mining & quarrying	Low	Small (1-10%)	Extreme (71-100%)	Moderate
3.3	Renewable energy	Negligible	Negligible (<1%)	Moderate (11-30%)	High
4	Transportation & service corridors	High	Large (31-70%)	Serious (31-70%)	High
4.1	Roads & railroads	Medium	Restricted (11-30%)	Serious (31-70%)	High
4.2	Utility & service lines	Low	Restricted (11-30%)	Moderate (11-30%)	Moderate
5	Biological resource use	Low	Small (1-10%)	Serious - Moderate (11-70%)	High
5.1	Hunting & collecting terrestrial animals	Negligible	Negligible (<1%)	Serious (31-70%)	High
5.2	Gathering terrestrial plants	Negligible	Negligible (<1%)	Unknown	High
5.3	Logging & wood harvesting	Low	Small (1-10%)	Serious (31-70%)	High
6	Human intrusions & disturbance	Low	Large (31-70%)	Slight (1-10%)	High
6.1	Recreational activities	Low	Large (31-70%)	Slight (1-10%)	High
6.2	War, civil unrest, & military exercises	Negligible	Negligible (<1%)	Negligible (<1%)	High
7	Natural system modifications	Low	Small (1-10%)	Serious (31-70%)	High
7.1	Fire & fire suppression	Unknown	Large (31-70%)	Unknown	High
7.3	Other ecosystem modifications	Low	Small (1-10%)	Serious (31-70%)	High
8	Invasive & other problematic species & genes	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High
8.1	Invasive non-native/alien species	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High
9	Pollution	Unknown	Small (1-10%)	Unknown	High
9.3	Agricultural & forestry effluents	Unknown	Small (1-10%)	Unknown	High
10	Geological events	Not calculated	Small (1-10%)	Serious (31-70%)	Unknown
10.1	Volcanoes	Not Calculated	Unknown	Unknown	Low
10.2	Earthquakes/tsunamis	Not calculated	Small (1-10%)	Serious (31-70%)	Unknown

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
10.3	Avalanches/landslides	Negligible	Negligible (<1%)	Moderate (11-30%)	Unknown
11	Climate change & severe weather	Not calculated	Restricted – Small (1-30%)	Slight (1-10%)	Low
11.2	Droughts	Unknown	Pervasive (71-100%)	Unknown	Low
11.4	Storms & flooding	Not calculated	Restricted - Small (1-30%)	Slight (1-10%)	Low

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: very high (75% declines), high (40%), medium (15%), and low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown).

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%)

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

Residential & commercial development: Calculated Impact – High; Scope – Large; Severity – Extreme (IUCN-CMP Threat 1)

Housing and urban areas (Threat 1.1) and Commercial and industrial areas (Threat 1.2)

Natural habitats, large ravines and riparian areas that represent core habitats for Oregon Forestsnail, coincide with the local government jurisdictions of Abbotsford, Mission, Chilliwack, Langley and Hope. Expanding human population in these lowland urban areas threatens habitat. Human activities associated with urban developments, specifically those that include clearing or removing Oregon Forestsnail habitat and/or altering natural hydrological patterns that result in habitat conditions that are too dry or wet for prolonged periods, can impact the microhabitat and overall forest stand structure necessary to sustain populations of Oregon Forestsnail.

At a minimum, there have been 73 separate urban housing developments within the core geographic range of Oregon Forestsnail (Abbotsford, Chilliwack, Agassiz, Maple Ridge, Mission and Langley). Of these developments, at least 17 urban housing developments (see Greater Vancouver Real Estate 2011) within the municipalities of Mission, Abbotsford (Figure 12), and Chilliwack appear to have resulted in direct natural deciduous forest habitat conversion and may have impacted Oregon Forestsnail habitat or populations (estimated from Google Earth satellite imagery viewing through Greater Vancouver Real Estate 2011). These urban developments include large-scale new communities with new infrastructure, such as schools, roads, and central shopping amenities and in some cases golf courses and other recreational infrastructure. Most of this development has been within privately owned natural land on Sumas Mountain and other areas of rural Abbotsford, Vedder Mountain, Whatcom and other natural areas of Chilliwack, within the Lower Fraser Valley (Greater Vancouver Real Estate 2011).

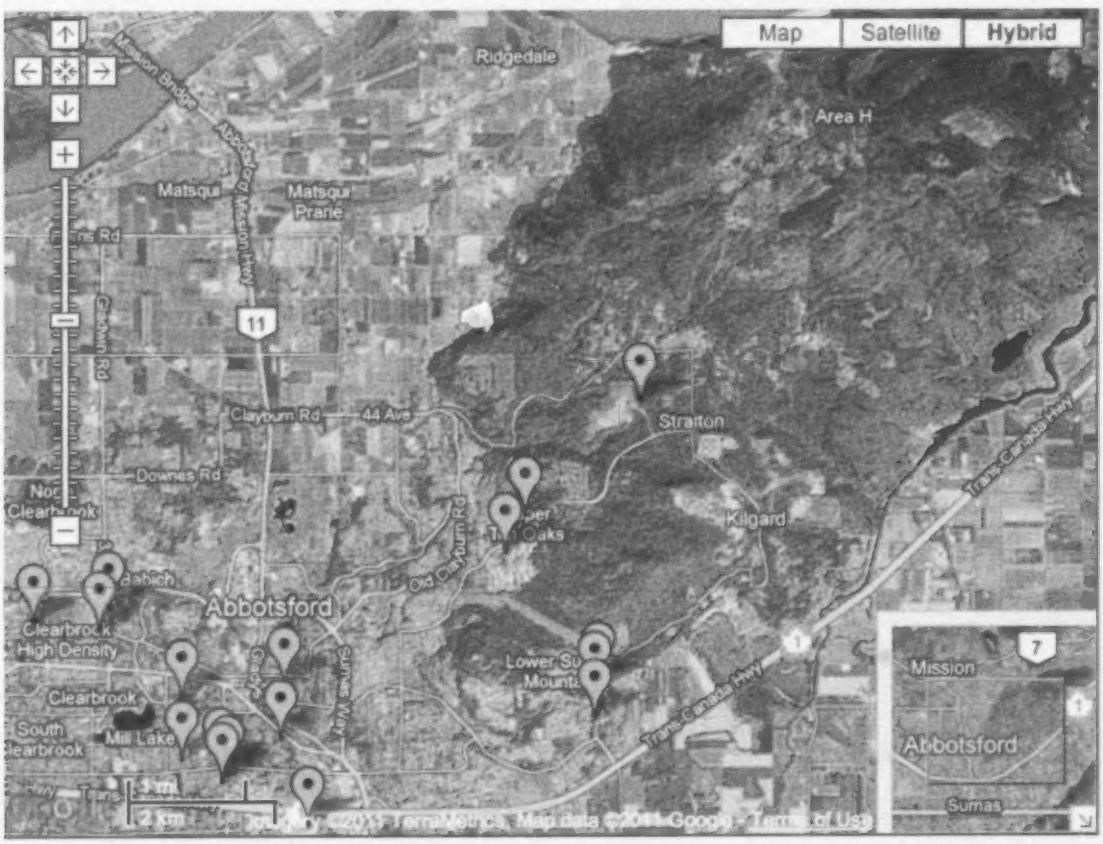

Figure 12. Urban housing projects (red dots on map) in the City of Abbotsford (Greater Vancouver Real Estate 2011). Note the large natural green area to the east is Sumas Mountain.

Today, most of the remaining large natural habitats within the core range of Oregon Forestsnail are in private ownership (either owned by the local government or by a private development company [proponent]) (Table 1). Each municipal government has an Official Community Plan with specific areas designated for future housing and commercial development to service the increase in human population. The *Local Government Act* requires a private landowner who is subdividing their property to dedicate 5% of the land subject to subdivision as a park or to pay cash in lieu of the land. This does not necessarily provide habitat for species at risk, however, as local government may be more inclined to take monetary compensation that can then be allocated to community projects elsewhere in the municipality over park land if the Official Community Plan does not designate the type and site of future parkland. As well, if someone is developing a property but is not subdividing (e.g., building a home, barn, etc.), this dedication is not required (Wetland Stewardship Partnership 2007). Some municipalities have environmentally sensitive development permit areas and can direct development away from these sensitive areas with high ecological (e.g., species at risk) values; however, if this is a gap in a municipality's Official Community Plan, then ecosystem values such as Oregon Forestsnail do not get protected.

Industrial and business park expansion plans are published for some municipalities within the Lower Fraser Valley, such as, for example, the City in the Country Plan specific to the City of Abbotsford. This plan projects the need for "1,300 acres of employment-generating industrial and business park lands over the next 20 years" with "future residential development accommodated through hillside development ... not accommodated by expansion into the Agricultural Land Reserve" (City of Abbotsford 2004).

Tourism and recreational areas (Threat 1.3)

The demand for tourism and recreational areas within the Lower Fraser Valley and southeastern Vancouver has increased substantially within the past decade. Natural areas continue to be developed into golf courses, campgrounds, parks and recreation facilities.

This threat applies to two known Oregon Forestsnail sites, although likely more sites because golf course or recreational developments within existing protected areas often are not accurately captured in threat assessments. In the past 10 years, numerous golf courses have been developed within the Lower Fraser Valley within natural habitat that may have had occurrences of Oregon Forestsnail: Abbotsford (two courses), Chilliwack (five courses), Langley (two courses), Aldergrove (part of Abbotsford) (one course), and Hope (one course).

Within existing parks, as well as regional and municipal properties, habitat conservation and recreational development potentially conflicts with Oregon Forestsnail conservation. Potential threats include construction of new trails and rights-of-way within highly used Metro Vancouver regional parks such as Colony Farm (Figure 10), Brunette-Fraser Greenway, Brae Island, Cheam Wetlands; creation of new camp sites (e.g., Hope and Chilliwack areas – at least two sites); creation of golf courses in the Abbotsford, Chilliwack, and Hope areas. For example, within Neilson Regional Park (Fraser Valley Regional District) there is a planned expansion of a children's playground into a large patch of Stinging Nettle where Oregon Forestsnail is known to occur (Heron pers. obs. 2011). In a separate site also within Neilson Park, Oregon Forestsnail is known to occupy patches of Stinging Nettle that border a baseball diamond.

Expansion of recreational areas increases the frequency of road and trail building, which may act as corridors (into natural habitats) that facilitate the rapid spread of invasive species (e.g., plant seeds attach to car tires and become dislodged at new sites) (Trombulak and Frissell 2000) and movement of non-native molluscs, especially *Arion* slugs (see IUCN-CMP Threat 8.1).

Transportation and service corridors: Calculated Impact – High; Scope – Large; Severity – Serious (IUCN-CMP Threat 4)

Roads and railroads (Threat 4.1)

With increasing human population comes the need for associated transportation infrastructure and access to both new and existing urban areas. Proposed transportation routes are often planned through areas that have the least impact to existing private landowners, e.g., land (frequently also natural areas) owned by the local or provincial government, land currently within the agricultural land reserve (although the land may be privately owned); or land through natural areas owned by one private landowner or company.

Oregon Forestsnail habitat includes ravines and gullies where both ephemeral and permanent natural watercourses flow. Proposed transportation routes through natural areas frequently result in changes to existing watercourses (e.g., if a roadway bisects a creek; ongoing road and highway expansion projects include plans to divert, infill and alter watercourses). At least 10 sites with Oregon Forestsnail have ongoing/finished major works within the past ten years (e.g., Marshall Road, Wren Creek, South Perimeter Road [Table 1]). Additional sites include areas near Westholme (Vancouver Island) along a railway right-of-way.

Within the range of Oregon Forestsnail extensive roads and other similar transportation corridors already fragment much of the remaining natural habitat and contribute to other threats including increased frequency of use by humans (IUCN-CMP Threat 6.1). Roadsides act as corridors into natural habitats and are known to facilitate the rapid spread of introduced species (e.g., plant seeds attach to car tires) (Trombulak and Frissell 2000) (see IUCN-CMP Threat 8.1). Roads are also effective barriers to snail dispersal and fragment habitat but also fragment and isolate populations that may have once been connected (Baur and Baur 1990).

Utility and service lines (Threat 4.2)

Service lines lead to population isolation and increased drought from edge effects and stand/wind penetration, leading to increased mortality and ecosystem changes through introduced species. Plans for expansion of hydro rights-of-way and infrastructure are ongoing throughout the Lower Fraser Valley, particularly in areas within large urban developments that require new/improved utility infrastructure. This threat applies to at least five known sites.

At present, there is ongoing construction of a transmission line from Coquitlam to Hope through much potential and unchecked habitat for Oregon Forestsnail. This habitat loss is not in the same areas as are the roads and the overall impacts are cumulative.

Invasive and other problematic species and genes: Calculated Impact – Medium-Low; Scope – Pervasive; Severity – Moderate-Slight (IUCN-CMP Threat 8)

Invasive non-native/alien species (Threat 8.1)

Introduced gastropods, invertebrates and plant species have been recorded from most Oregon Forestsnail habitats, although the scope of introduction and suite of species present is not fully known. Greater than 90% of sites have introduced species present, particularly Himalayan Blackberry (*Rubus armeniacus*) and other non-native plants, introduced gastropods, earthworms and various introduced carabid beetles. Invasive terrestrial gastropods can potentially out-compete and prey upon Oregon Forestsnail.

Introduced invertebrates, particularly introduced gastropods, may pose a threat to Oregon Forestsnail through competition for food and shelter or through predation. Rollo and Wellington (1979) demonstrated intra- and interspecific aggression among slugs and competition for refuges. Introduced gastropods of European origin are widespread within urban and agricultural areas within the Lower Fraser Valley and southern Vancouver Island, and several species have penetrated forested habitats (Forsyth 1999b, 2001). These species continue to spread into new areas with inadvertent assistance from humans when nursery plants, garden ornamentals, or other materials with adhering soil are transported or when garden waste is discarded (Forsyth 1999b). Roads are also known to increase the spread of introduced species and predation pressure on gastropods (Trombulak and Frissell 2000).

Three introduced species locally common in the Lower Fraser Valley, Giant Gardenslug (*Limax maximus*), Dusky Arion (*Arion subfuscus*), Chocolate Arion (*Arion rufus*) and Longneck Fieldslug (*Deroceras invadens)*, are particularly aggressive. The introduced, carnivorous Dark-bodied Glass-snail (*Oxychilus draparnaudi*) is locally common in southern Vancouver Island (Victoria area) and greater Vancouver areas (Forsyth 1999b) and probably also occurs within the range of Oregon Forestsnail in the Lower Fraser Valley. Dark-bodied Glass-snail could potentially be a significant predator of Oregon Forestsnail eggs and young (Ovaska pers. comm. 2012). This species has been identified as a potential threat to native gastropods in other areas where it has been introduced (Frest and Rhodes 1982). Other introduced gastropod species that may compete with Oregon Forestsnail include Grovesnail and other species of slugs, such as the Chocolate Arion and the Gray Fieldslug (*Deroceras reticulatum*).

Although most invasive gastropods are primarily in areas of high human use and alteration, some have spread into intact coniferous forest habitats and increased their range (Ovaska pers. comm. 2012). Within forests in Washington State, Chocolate Arion is documented from within old growth forests, and may be displacing native Banana Slug (*Ariolimax columbianus*) (Burke *et al.* 1999). Concentration of snails into small habitat patches with less overall shelter and escape cover is likely to increase their vulnerability to predation.

Some invasive plant species are known to change the forest floor vegetation and soil structure and facilitate an increase in light penetrating to the forest floor. Increases in light levels lead to dryer microclimate, understory conditions and forest floor desiccation, and increases dehydration stress to gastropods that depend upon high water and humidity levels. Invasive plants, such as English Holly (*Ilex aquifolium*) and Spurge-laurel (*Daphne laureola*) are likely to invade disturbed areas. English Ivy (*Hedera helix*) is known to spread and displace native vegetation on forest floors. English Holly and Himalayan Blackberry are also widely spread invasive plants within native ecosystems within southern Vancouver Island, and are known to displace native vegetation and may impact native Stinging Nettle. Oregon Forestsnail appears to be able to survive within habitat that has Himalayan Blackberry (e.g., Colony Farm Regional Park [Figure 10]).

The threat of invasive species likely exists at all Oregon Forestsnail sites; however, there is some uncertainty of the impact.

Human intrusions and disturbance: Calculated Impact – Low; Scope – Large; Severity – Slight (IUCN-CMP Threat 6)

Recreational activities (Threat 6.1)

Recreational activities within Oregon Forestsnail habitat include camping, hiking (e.g., Sumas Mountain Regional Park), foot and bicycle traffic (e.g., Brunette-Fraser Regional Greenway), horseback riding (Campbell Valley Regional Park [Figure 7]) and the use of all terrain vehicles (ATVs) and trail bikes (e.g., private land), especially off-trail bikes (e.g., Sumas Mountain). Such activities can result in degradation of habitat quality through soil compaction and can also cause accidental mortality especially along trail edges.

Effects from recreational activities can be pronounced in areas where the species is restricted to small habitat patches (e.g., Brunette-Fraser Regional Greenway – Metro Vancouver Regional District; Neilson Regional Park – Fraser Valley Regional District). For example, inadvertent trampling of the site could result in significant mortality, especially during the spring breeding period when the snails are active.

Areas with particularly high recreational use include habitats within Metro Vancouver and Fraser Valley regional districts parks; habitats on Sumas Mountain on BC Crown and private land (including local government land); portions of the TSU-ESA, and provincial parks such as Cultus Lake Provincial Park (Chilliwack) and Bridal Veil Falls Provincial Park (outside Hope) (Figure 9).

Hiking, ATV and related activities may also increase the spread of introduced species (see IUCN-CMP Threat 8.1). Recreational use of trails for horseback riding also likely impacts habitat (e.g., trampling of trails/edges and defecation which increases the spread of fungus, seeds, etc.).

The threat of recreational activities applies to at least 58 sites, although at many sites the damage to the species or its habitat is likely limited in scope to trail sides.

War, civil unrest and military exercises (Threat 6.2)

Activities occurring on DND land that are considered necessary for national security include not only military training but training by other organizations, such as police. The Canadian Forces and Royal Canadian Mounted Police (RCMP) both conduct dismounted (on foot) training in forested areas belonging to DND. In addition to training, development to meet operational requirements and maintenance (such as road maintenance) are necessary on training areas to maintain their usefulness.

Populations of Oregon Forestsnail on DND land have been found away from roads in forested areas that will continue to be maintained as such, and are only occasionally used for dismounted training. Although training has been ongoing at one site for over 25 years, the soils do not appear to have been compacted. The fact that there are still extant populations with juveniles indicates that this threat is negligible.

Agriculture and aquaculture: Calculated Impact – Low; Scope – Restricted; Severity – Moderate (IUCN-CMP Threat 2)

Annual and perennial non-timber crops (Threat 2.1)

Coniferous forest habitat that is within the agricultural land reserve is subject to clearing and conversion. In some cases, landowners/managers may clear land in anticipation of agricultural development, although no actual crops, grazing or agricultural practices will occur on the land for a number of years. At present, there is no environmental assessment required for species at risk presence surveys prior to the clearing of land for agriculture. This is a potential threat at many agricultural sites within the Lower Fraser Valley with verges of natural habitat surrounding the agricultural field (e.g., Oregon Forestsnail has been observed adjacent to fields) (Bianchini pers. comm. 2012). This applies to remnant areas of habitat (e.g., ditchside verges, crop verges and the perimeter of agricultural fields) where Oregon Forestsnail may remain in small habitat patches.

Wood and pulp plantations (Threat 2.2)

Wood and pulp plantations are throughout the Chilliwack and Hope areas. The first hardwood tree-farm licence in the Lower Fraser Valley was granted in 1985 and as a result much of the old growth cottonwood stands were harvested (Pollon 2010). Conifer plantations do not manage for a diverse multi-layer understory. Small gaps in wet areas may act as a population sink where Oregon Forestsnail may remain. As well, ongoing harvesting within these stands continues to take place and destroy habitat and these remaining patches.

Livestock farming and ranching (Threat 2.3)

Detrimental impacts to Oregon Forestsnail habitat from livestock grazing have been recorded from at least three sites (BC Conservation Data Centre 2013). The impacts to gastropods from grazing are unknown, but trampling of sensitive riparian areas is often a result of livestock congregating near watercourses and there would be direct mortality caused by trampling of individuals and habitat (e.g., Stinging Nettle and other herbaceous plants).

Energy production and mining: Calculated Impact – Low; Scope – Small; Severity – Extreme (IUCN-CMP Threat 3)

Mining and quarrying (Threat 3.2)

Gravel mining is a localized threat at sites in the Lower Fraser Valley, particularly on areas of Sumas Mountain. The overall footprint is small at this time but may expand in the future and results in complete habitat loss where it occurs.

Renewable energy (Threat 3.3)

Independent Power Projects are numerous throughout the Lower Fraser Valley and impact potential habitat (riparian areas) where Oregon Forestsnail may occur. The overall footprint from these power projects is small; however, the cumulative riparian habitat loss due to these substations has potential to impact the species overall.

Biological resource use: Calculated Impact – Low; Scope – Small; Severity – Serious-Moderate (IUCN-CMP Threat 5)

Hunting and collecting terrestrial animals (Threat 5.1)

There are a few observations of citizens collecting terrestrial snails for consumption (Bianchini pers. comm. 2012); therefore, the scope of this threat is negligible at this time. It is also likely that once an individual has removed the readily available snails (e.g., they've cleaned out the snails, up to 70% in an area), the same area will not be revisited in the future.

Gathering terrestrial plants (Threat 5.2)

Stinging Nettle is of cultural significance to First Nations people in the region. As well, many people consume the plant. With an increased awareness of local native plants, the consumption of native species and the widespread social trend to consume locally grown produce, some local farms provide Stinging Nettle. It is likely that these farms are just gathering the plant and not cultivating it (e.g., crops). Currently, this threat has a negligible impact on Oregon Forestsnail.

Logging and wood harvesting (Threat 5.3)

The BC range of Oregon Forestsnail has been impacted from extensive historical logging and forest resource extraction activities. The forest land base, particularly within the rural areas of Mission, Chilliwack and Hope, continues to be intensively managed due to the high demand for forest products. Forest management practices, including pre-commercial thinning, pruning, removal of select tree species, fertilization, patch-size harvesting, and clear-cut harvesting, likely have detrimental effects on populations of Oregon Forestsnail.

Pre-commercial thinning and pruning reduce the quantity and/or alter the timing of leaf and branch litter that would otherwise fall to the forest floor and provide shelter for Oregon Forestsnail. Pruning that removes lateral branches reduces the overall forest canopy, which results in lower relative humidity and subsequent desiccation of the forest floor. The removal of trees and use of machinery may compact ground cover, crush individuals of Oregon Forestsnail, disturb coarse woody debris and shelter sites, and cause localized impacts. Present-day intensive forest management practices target large dead coarse woody debris removal during the second rotation of harvesting. Thus, large coarse woody debris may be in short supply in intensively managed forests. These logs are likely important for maintaining stable microclimates for developing eggs, and thus suitable microhabitat for Oregon Forestsnail.

Harvest of forest stands isolates subpopulations further, decreases available habitat and increases drought from edge effects and stand/wind penetration, leading to increased mortality and ecosystem changes through introduced species. Numerous Oregon Forestsnail records are from provincial Crown land operating under the Chilliwack Forest District (BC Ministry of Forests, Lands and Natural Resource Operations 2012). The Chilliwack Forest District covers approximately 1.4 million ha (BC Ministry of Forests, Lands and Natural Resource Operations 2012). Stands under 350 m elevation are potential Oregon Forestsnail habitat.

Areas on Sumas and Vedder Mountain still have small habitat patches used for logging, although once logged the land use will likely change. Hope and Chilliwack (easternmost range extent) have ongoing logging. This threat applies to 11 sites.

There is also ongoing illegal harvest of older growth cedar and hardwood trees throughout the range of Oregon Forestsnail. The impacts of illegal harvest are unknown.

Natural system modifications: Calculated Impact – Low; Scope – Small; Severity – Serious (IUCN-CMP Threat 7)

Fire and fire suppression (Threat 7.1)

Burke *et al.* (1999) cite fire as a threat to gastropod populations in Washington State. The threat of fire is present throughout the entire range of Oregon Forestsnail, particularly within large natural tracts of land, areas adjacent to roadways and rights-of-way and in recreational areas where campfires occur.

Deciduous forests within the range of Oregon Forestsnail remain moist and wet throughout the year, but the threat of forest fires is possible, particularly in July through September.

Human activities that increase the threat of fire include careless attendance to campfires, discarded cigarettes, improperly wired camping equipment and machinery. Forests fires occur yearly, although efforts are made to control the frequency, size, and spread of fire through fire suppression programs (e.g., brush burning).

Brush clearing, piling and periodic burning of vegetation and woody debris occur on private and public lands throughout the range of Oregon Forestsnail. Although burning would only impact small areas of land, there is the possibility of overlap with unknown occurrences of Oregon Forestsnail. The smoke generated from periodic brush burning, and the resultant char and burned debris are also detrimental to habitat quality.

All Oregon Forestsnail sites are threatened by fire, however not at the same time. If or when a fire will occur at a particular site is unknown thus the overall impact from fire is unknown.

Other ecosystem modifications (Threat 7.3)

Mowing and cutting of vegetation within sites (often as a form of fire suppression) adversely affects Oregon Forestsnail. Removal of vegetation may impact Oregon Forestsnail through decreasing available moisture retention within habitats and increasing dehydration stress to individuals and direct mortality as gastropod activity patterns predominantly coincide with preventing dehydration (Prior 1985). This threat is present throughout a small portion of its range especially at the urban interface; roadsides, trails and other right-of-ways; agricultural areas and in recreational areas to control campfires.

The close association Oregon Forestsnail has with Stinging Nettle may indirectly be detrimental to Oregon Forestsnail habitat. This is because Stinging Nettle may be targeted for removal in recreational areas with high human use due to the plant's ability to irritate skin.

Pollution: Calculated Impact – Unknown; Scope – Small; Severity – Unknown (IUCN-CMP Threat 9)

Agricultural and forestry effluents (Threat 9.3)

The use of pesticides, especially those aimed at gastropods, has potential to harm Oregon Forestsnail populations by directly killing both individuals and eggs. The only application of pesticides that specifically target gastropods that is likely to occur is on privately owned properties within close proximity to houses, barns or other human structures where Oregon Forestsnail is mistaken for a pest species. Overall, the general use of herbicides within parks and protected areas is diminishing due to municipal and regional bylaws that limit the use of these chemicals (e.g., City of Richmond). Provincial initiatives that consider the ban on home use of pesticides for cosmetic purposes throughout BC are ongoing (Nagel 2011). However, pesticide bans are controversial in some municipalities (e.g., Cassidy 2011).

Agricultural and forestry effluents are likely to cause harm to Oregon Forestsnail habitat and individuals. For example, the use of herbicides to control regeneration of Bigleaf Maple on commercial forestry lands may also impact snail populations in adjacent, mature stands, through run-off. Young Bigleaf Maple regeneration within conifer plantations competes with commercial tree species, and herbicide treatments (either stump or foliage applications) are applied to control competing vegetation. This herbicide treatment can potentially harm or reduce habitat available to land snails.

Oregon Forestsnail is frequently recorded from forest and trail edge habitats, with at least three sites known to occur adjacent to well-used recreational trails within urban parks. Other land snails, such as Copse Snail (*Arianta arbustorum*) prefers moving along road verges and avoids crossing roads, including unpaved roads only 3 m wide (Baur and Baur 1990). Spraying herbicides (and mowing, see above) to control road or trail-side vegetation likely harms gastropods within these verges, and the cumulative and persistent effects of herbicides within these environments may lead to long-term declines in gastropod numbers. Herbicides are used less today and many municipalities have bans on certain herbicides, but it is unclear how extensive this practice was (or is currently) within the range of Oregon Forestsnail.

It is possible agricultural run-off could impact the species. The snail has been found adjacent to agricultural and urban run-off areas, but the overall impact to the species is unknown. Increasing blueberry acreage throughout the Lower Fraser Valley includes many sites potentially adjacent to Oregon Forestsnail habitat. Concern for fruit pests such as Spotted Wing Drosophila (*Drosophila suzukii*) has resulted in intensive spraying of hedgerows, riparian areas and other vegetation that includes wild fruits capable of serving as refuge for Spotted Wing Drosophila. This may in turn be a problem for edge species such as Oregon Forestsnail. Pesticides and fertilizers threaten Oregon Forestsnail in much of the suitable habitat, particularly adjacent to the urban/agricultural interface.

This threat applies to 13 known sites, although there are likely additional sites adjacent to agricultural areas where effluent run-off occurs. The impact of this threat is unknown and requires study.

<u>Geological events: Calculated Impact – Not calculated; Scope – Small; Severity – Serious (IUCN-CMP Threat 10)</u>

Earthquakes/tsunamis (Threat 10.2)

Oregon Forestsnail records and potential habitat includes areas of the Lower Fraser Valley that could potentially be impacted from rising water levels as a result of earthquakes or tsunamis. The timing of such events, however, is unknown.

Avalanches/landslides (Threat 10.3)

Oregon Forestsnail habitat includes steeper hillsides and riparian areas where minor landslides and washouts could occur, particularly in areas with unstable historical road construction and improper culvert drainage. The forested areas of Chilliwack and Hope are where this threat is most likely to apply. Overall, this threat is thought to be negligible because the scope is negligible.

Climate change and severe weather: Calculated Impact – Not calculated; Scope – Restricted-Small; Severity – Slight (IUCN-CMP Threat 11)

Droughts (Threat 11.2)

Increased summer droughts may affect occupied Oregon Forestsnail habitats and will decrease the available site moisture that allows for suitable microhabitat. Combined with other threats, such as water diversion and infilling, drought within natural habitat may increase in the next ten years. The impact of this threat is unknown.

Storms and flooding (Threat 11.4)

Some areas of Oregon Forestsnail habitat such as the valley bottom within the Lower Fraser Valley is within the potential flood zone of the Fraser River (BC Ministry of Environment 2011b). The greatest vulnerability to flood risk within the range of Oregon Forestsnail includes parts of Langley, Pitt Meadows, Chilliwack, Kent, Abbotsford, Tsawwassen, Mission, Hope, Port Coquitlam and Surrey (Fraser Basin Council 2011). The Lower Fraser Valley has experienced major floods: the largest in 1894 and the second largest in 1948. Within the next 50 years there is a one-in-three prediction that a flood of similar magnitude will occur within the Lower Fraser Valley (Fraser Basin Council 2011). Overall the severity of this threat is slight.

Number of Locations

The most serious, predominant threat to Oregon Forestsnail in Canada is IUCN-CMP Threat #1 Residential and Commercial Development, which is likely to affect most large pieces of private riparian and lowland forested land. At present there are 66 known occupied sites for Oregon Forestsnail spanning at least 95 different landowners (e.g., property where Oregon Forestsnail habitat spans numerous landowners but ownership is unknown). At least 56 sites are privately owned (including local government land which is considered private land in BC). If each separate parcel of land occupied by the snail and owned by a different person, business, or organization is considered a location, then the number of locations for the Oregon Forestsnail in Canada is well above the COSEWIC threshold of 10 given the rate and scope of development will most likely vary among owners.

Limiting Factors for Oregon Forestsnail

Dispersal ability

The dispersal ability of Oregon Forestsnail is likely poor, and it is unclear how much habitat is required to sustain a population within a site or habitat patch. By their very nature, snails are sedentary and cryptic animals, and their natural ability to colonize new areas is likely poor.

Northernmost extent of global range

Oregon Forestsnail is at the northernmost extent of its global range, which likely increases the species' susceptibility to climatic changes and stochastic population fluctuations.

Require humid environments

When the forest floor becomes increasingly exposed to wind and sunlight and there is less vegetation growing throughout the understory, terrestrial molluscs are more vulnerable to dehydration (Prior 1985; Burke *et al.* 1999) and experience high rates of evaporative water loss through their skin (Dainton 1954a,b; Machin 1964a,b,c; Burton 1966; Prior 1983; Prior *et al.* 1983; Prior 1985). Snails are known to initiate "water seeking" responses to dehydration after a short-term reduction in locomotor activity (Prior 1985). The physiology and activity patterns of Oregon Forestsnail inherently make them susceptible to continuous water loss through dehydration. All snails deposit a dilute mucus trail, and experience constant evaporative water loss through the lung surface and integument. Numerous ecological and physiological studies show a relationship between body temperature, hydration and locomotor activity (Machin 1975; Peake 1978; Burton 1983; Riddle 1983; Martin 1983 as cited in Prior 1985). Within two hours, active slugs can lose 30 – 40% of their initial body weight and habitat selection by slugs is correlated with water availability (Prior 1985). Although this information pertains to slugs, it is likely similar for Oregon Forestsnail.

Soil mineral composition

Soil mineral content (including magnesium and calcium) and pH may play an important factor in snail microhabitat preference. Although unstudied in Oregon Forestsnail, these factors have been known to affect habitat preferences in other gastropods (Wareborn 1969; Hylander *et al.* 2004).

Native predators

Potential native invertebrate predators include the carnivorous snail Robust Lancetooth and ground beetles (e.g., Snail-killer Carabid, *Scaphinotus angusticollis*) (Ovaska pers. comm. 2012; Sopuck pers. comm. 2012). Both species are believed to be gastropod specialists (Thiele 1977) and will follow the mucus trails of slugs. Robust Lancetooth has been observed to attack and kill slugs (Ovaska and Sopuck unpubl. data 2000). These (and other) invertebrate predators are common throughout the same habitats as Oregon Forestsnail although there are no known obligate associations. Concentration of predators in small habitat patches where little escape cover is available will potentially increase predation rates on Oregon Forestsnail. Competition and predation as a limiting factor may become more of a threat when combined with competition and predation from introduced species and further development pressures.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

Oregon Forestsnail is protected under the federal *Species at Risk Act* (SARA) although protection is currently applied only on federal properties. SARA can provide immediate protection for individuals and their residences and includes provisions for the protection of critical habitat once identified in a recovery strategy. Oregon Forestsnail was originally assessed by COSEWIC as Endangered in 2002 (COSEWIC 2002) and was included on Schedule 1 of SARA as Endangered in 2003 when the Act was proclaimed. The residence concept under SARA does not apply to all species and as of October 2011, a residence description for Oregon Forestsnail has not been posted on the SARA Public Registry. Similarly, a finalized recovery strategy has not yet been posted on SARA, and critical habitat for the species has not yet been formally defined (Harrison pers. comm. 2012; Tanaka pers. comm. 2012). However, the provincial recovery plan has been approved (Oregon Forestsnail Recovery Team 2012).

Oregon Forestsnail would be protected within national parks and national historic sites under the *National Parks Act* if they were present. There is the possibility Oregon Forestsnail could be within Fort Langley National Historic Site. To date, there have not been surveys to confirm its presence but there is a known population within 1 km of the historic site.

The BC *Park Act* protects invertebrate species at risk (Red and Blue-listed species) in provincial parks and protected areas. When species at risk and their habitats are known to occur within a protected area, provisions for management are incorporated into the park master plan. Further, the BC *Ecological Reserves Act* provides protection for species (Red and Blue-listed) occurring within ecological reserves in BC.

Invertebrates assessed by COSEWIC as Threatened, Endangered or Extirpated will be protected through the BC *Wildlife Act* and *Wildlife Amendment Act* (Province of BC 1982) once the regulations listing these species are completed; however, they are currently not protected under these provincial Acts.

Non-Legal Status and Ranks

Oregon Forestsnail has a conservation status rank of S1S2 (critically imperilled-imperilled) in BC (BC Conservation Data Centre 2013) and is nationally ranked (Canada) as N1N2 (critically imperiled-imperilled) (NatureServe Canada 2012). The global conservation status rank is G3G4 (vulnerable-apparently secure) (NatureServe 2012). In Washington State the species has a conservation status rank of S3S4 (vulnerable-apparently secure) and in Oregon State the conservation status rank is SNR (status not ranked) (NatureServe 2012).

Oregon Forestsnail is a Priority 1 species (highest priority) under Goal 3 (maintain the diversity of native species and ecosystems) of the BC Conservation Framework (BC Ministry of Environment 2011a). Provincial staff responsible for Oregon Forestsnail conservation are aware of the habitat requirements of this species, and advise other staff to look out for possible new occurrences (Chatwin pers. comm. 2012; Hirner pers. comm. 2012; Robbins pers. comm. 2012; Welstead pers. comm. 2012).

Non-government conservation organizations, such as the South Coast Conservation Program (Robbins pers. comm. 2012; Welstead pers. comm. 2012) and Fraser Valley Conservancy (MacMillan pers. comm. 2012), outline stewardship opportunities and work with private landowners toward protecting Oregon Forestsnail habitat on private lands. Conservation organizations such as the Fraser Valley Conservancy (MacMillan pers. comm. 2012) and the Victoria Natural History Society (Copley pers. comm. 2012) include information on Oregon Forestsnail in their public newsletters.

Habitat Protection and Ownership

Most land within the range of Oregon Forestsnail is privately owned (Table 1). Ownership is by individuals (e.g., farms or rural properties), private forest companies (e.g., for timber production), land developers (e.g., with future plans for urban housing or industrial real estate uses), or local governments (e.g., watersheds and natural areas or future urban/commercial real estate development).

The only federal property known to have a population of Oregon Forestsnail and therefore potentially under habitat protection provisions of SARA is at ASU Chilliwack. Intensive surveys within other federal properties within the known range of Oregon Forestsnail, such as Canadian Forces Base (CFB) Aldergrove, Gulf Islands National Park Reserve and Pacific Rim National Park Reserve have not yielded records. The ongoing use of military Range and Training Areas within ASU Chilliwack must comply with existing federal environmental legislation and departmental environment

stewardship policies and requires military training be completed in a way that does not compromise environmental sustainability and values (Manweiler pers. comm. 2012). The responsible environmental officers have outlined habitat important for Oregon Forestsnail. A management plan is in place to prevent harm to individuals or destruction of important snail habitat (Manweiler pers. comm. 2012). Oregon Forestsnail has been recorded throughout most of the suitable habitat on the property (Hawkes and Gatten 2011). While the approximate size of the federal property is 644 ha, the amount of potential habitat is estimated at 397 ha but can be further reduced by removing unsuitable habitat for the snail i.e., areas of dense forest and a coniferous swamp with no Stinging Nettle. The actual area of occupancy at the site is unknown.

Oregon Forestsnail also has been recorded from four federal Indian Reserves totalling approximately 19 ha: Sahhacum Indian Reserve 1 (Abbotsford) (< 1 ha), Squiaala Indian Reserve 7 (Chilliwack) (5.39 ha); Popkum Indian Reserve 2 (near Hope) (< 3.9 ha), and Halalt Indian Reserve at Westholme near Crofton (8.8 ha).

There is no legislative protection specifically for Oregon Forestsnail habitat on provincially or privately owned lands in BC although it is recommended for listing as Identified Wildlife under the BC *Forest and Range Practices Act* (Province of BC 2002). At present, the species is not listed under this Act, although once listed it will be possible to protect known sites and habitat within Wildlife Habitat Areas on provincial Crown land.

Oregon Forestsnail has been recorded from two provincial parks: Bridal Veil Falls Provincial Park (< 1 ha area of occupancy within Stinging Nettle, Figure 9) and Cultus Lake Provincial Park (< 1 ha area of occupancy). The snails in the park are afforded protection through the legal provisions of the *BC Parks Act*. Both parks are popular recreational areas but there are currently no specific management provisions within the respective park master plans. Park staff are aware of the Oregon Forestsnail occurrences (Hirner pers. comm. 2012).

Oregon Forestsnail populations have been recorded from four private conservation areas in the Lower Fraser Valley. One is the TWU-ESA, which is approximately 50 ha of habitat that is partially covenanted under the BC Ministry of Environment for the protection of fish habitat. The other three properties are owned and/or managed by the Fraser Valley Conservancy (MacMillan pers. comm. 2012): South Fraser Way (1 ha); Auchenway (0.5 ha); and McKee Property (8 acres). Another property is managed by Fraser Valley Conservancy, but owned by the City of Abbotsford (MacMillan pers. comm. 2012).

Numerous Oregon Forestsnail records are from provincial crown land operating under the Chilliwack Forest District (BC Ministry of Forests, Lands and Natural Resource Operations 2012). The Chilliwack Forest District covers approximately 1.4 million ha (BC Ministry of Forests, Lands and Natural Operations 2012). Approximately 10 sites (Table 1) are known to occur on provincial crown land.

Oregon Forestsnail has been recorded from eight local government parks within the Lower Fraser Valley. The approximate area of occupancy is greater than 11 ha. Metro Vancouver (regional district) land managers are aware of the Oregon Forestsnail and are working to incorporate best management practices into park maintenance planning within parks where the species has been recorded (Central Area Parks, Evely pers. comm. 2012; East Area Parks, Jarvis pers. comm. 2012; West Area Parks, Merkens pers. comm. 2012). Metro Vancouver parks with Oregon Forestsnail records and habitat include Colony Farm Regional Park (Figure 10); Brunette-Fraser Regional Greenway; Brae Island Regional Park and Glen Valley Regional Park. Fraser Valley Regional District is also aware of the snail and associated habitat within Cheam Lake Wetlands Regional Park, Aldergrove Regional Park and Neilson Park (Gadsden pers. comm. 2012; Jones pers. comm. 2012). Other parks with records of Oregon Forestsnail include Douglas Taylor Park (City of Abbotsford).

Proposed urban development requires various types of permitting under local, provincial and federal government policy and legislation. The scale, scope and impact of the development determine the type of permitting. As part of the environmental planning process, a proponent is required to apply for a development permit to local government.

Local government bylaws that protect environmental values differ among the 13 local governments (municipal and regional) known to have Oregon Forestsnail sites and unchecked habitat. There are no local (municipal and regional) government bylaws that specifically protect Oregon Forestsnail individuals or habitat; however, numerous development permit applications (depending on the jurisdiction) require environmental assessments that include wildlife values and consider impacts to natural habitats as part of the approval process. Part of the environmental assessment process requires wildlife surveys, which could reveal populations of Oregon Forestsnail within the planned development. Some municipalities have an Official Community Plan that designates environmentally sensitive development permit areas and can direct development away from these sensitive areas with high ecological (e.g., species at risk) values.

The most important legislation that has the potential to protect Oregon Forestsnail habitat is the BC *Water Act* (Province of BC 1996). Because the snail's habitat includes ravines, riparian areas and wetland edges, including seasonal and permanent wetlands, and often is adjacent to natural watercourses, it is indirectly protected through provisions of this Act. The Act states the ownership of water is vested in the Crown. A "stream" "*includes a natural watercourse or source of water supply, whether usually containing water or not, and a lake, river, creek, spring, ravine, swamp and gulch.*" Under the *Water Act* (Province of BC 1996), "changes in and about a stream" means:

1) any modification to the nature of the stream including the land, vegetation, natural environment or flow of water within the stream, or

2) *any activity or construction within the stream channel that has or may have an impact on a stream.*

Section 9 of the *Water Act* (Province of BC 1996) requires that a person may only make "changes in and about a stream" under an Approval or under a Water Licence or Order. Prior to receiving an Approval the proponent must address wildlife resource values among many other components. Advice by other regulatory agencies within the provincial government is often sought to determine the impacts to wildlife resource values. Oregon Forestsnail is considered an ecological value. Because Oregon Forestsnail habitat often overlaps with habitat needed to conserve and protect the water resources and values, the effects to its habitat from infilling, diverting or channelling existing natural watercourses to accommodate access and new urban development is frequently considered during this decision process. However, this potential habitat protection mechanism does not guarantee protection for the snail. Proponents often propose infilling, channelling and diverting water supplies followed by salvage and translocation of snails to different habitats. While there is no legislative requirement to conduct salvage, salvage is not a known viable long-term option for protecting Oregon Forestsnail individuals and habitat. In some cases, monitoring of salvaged populations is required as part of the *Water Act* approval (e.g., urban development on Mount Lehman, Abbotsford) but salvage of individual snails does little to protect habitat.

Oregon Forestsnail habitat is also indirectly protected under provisions in the Riparian Areas Regulation under the BC *Fisheries Act*, which requires habitat buffers to remain around watercourses (depending on the size of the watercourse); however, habitat buffer sizes are often not large enough to protect the entire population of the snail.

Despite the potential habitat protection provisions with the BC *Water Act* and BC *Fisheries Act*, there are at least five examples of BC *Water Act* Section 9 Approvals in the past four years that allowed the diversion of a watercourse and infilling of riparian habitat with Oregon Forestsnail populations (e.g., Port Mann Bridge Highway expansion project [Surrey]; Wren Street and Lougheed Highway [Mission]; Silverdale [Mission]; Mount Lehman [Abbotsford]; Marshall Creek ravine [Abbotsford]) (Malt pers. comm. 2012; Robbins pers. comm. 2012).

One example of a *Water Act* Section 9 approval involves infilling and loss of 500 m^2 of in-stream habitat, 53,900 m^2 of riparian habitat, and 9600 m^2 of active floodplain habitat. This development will enable a large urban housing development to be built on the land, much of which is occupied Oregon Forestsnail habitat.

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Jennifer Heron is the provincial invertebrate conservation specialist with the BC Ministry of Environment, Terrestrial Conservation Science Section. She directs and manages the provincial approach to invertebrate conservation, including the development and implementation of provincial legislation, policy, procedures, and standards for the conservation and recovery of invertebrate species at risk, their habitats and ecosystems, and to keep these species from becoming at risk. She works with other invertebrate specialists to develop recovery-planning approaches and assign conservation status ranks to invertebrate groups. She works with local conservation and stewardship groups to achieve common public outreach goals.

COLLECTIONS EXAMINED

The following institutional collections were consulted as part of the COSEWIC (2002) status report for Oregon Forestsnail:

Canadian Museum of Nature [CMN], PO Box 3443, Stn. D, Ottawa, ON, Canada K1P 6P4 (museum records).

The Field Museum of Natural History [FMNH], 1400 S. Lake Shore Drive, Chicago, IL, USA 60605-2496

Royal British Columbia Museum [RBCM], 675 Belleville Street, Victoria, BC, Canada V8V 1X4

The following institutions reported that they have no holdings of Oregon Forestsnail (COSEWIC 2002):

Delaware Museum of Natural History [DMNH], 4840 Kennett Pike, PO Box 3937, Wilmington, DE, USA 19807-0937

The Philadelphia Academy of Natural Sciences [ANSP], 1900 Benjamin Franklin Parkway, Philadelphia, PA, USA 19103

Royal Ontario Museum [ROM], 100 Queen's Park, Toronto, Ottawa, ON, Canada M5S 2G6

Smithsonian Institution [USNM], Washington, DC, USA 20560-0163

Appendix 1. List of Oregon Forestsnail Museum and Collection Records up to 2001. CMH: Canadian Museum of Nature, Ottawa; RBCM: Royal British Columbia Museum, Victoria; FMNH: Field Museum of Natural History, Chicago.

Museum No./ Published record	Site	Geoposition	Year	Date	Number Individuals /specimens
CMN 002988; Whiteaves 1906	Chilliwack River		1901	1901-VI-20	1
CMN 002995	E&N railroad ¼ mi. NW of Westholme Station, Vancouver I.		1903		2
CMN 008003	SW of Abbotsford	49°02′N, 122°18′W	1954	1954-VI-27	10
CMN 007182	E side of Abbotsford	49°02′N, 122°18′W	1954	1954-VI-27	4
CMN 008164	South shore of Fraser River, Chilliwack	49°06′N, 121°56′W	1959	1959-05-24	5
CMN 008234	Vedder Crossing		1959	1959-07-17	6
CMN 008134	S shore of Fraser River, Chilliwack	49°06′N, 121°56′W	1959	1959-V-15	3
CMN 008125	Vedder Crossing		1959	1959-V-21	2
CMN 008145	Vedder Crossing		1959	1959-V-21	2
CMN 008038	Vedder Crossing		1959	1959-V-25	1
CMN 008147	Prairie Central & Patterson Rd., Chilliwack		1959	1959-V-26	1
CMN 008045	S shore of Fraser River, Chilliwack	49°06′N, 121°56′W	1959	1959-V-29	1
CMN 008596	South shore of Fraser River, Chilliwack	49°06′N, 121°56′W	1959	1959-V-29	1
CMN 008948	South shore of Fraser River, Chilliwack	49°06′N, 121°56′W	1959	1959-V-29	20
CMN 008944	South shore of Fraser River, Chilliwack	49°06′N, 121°56′W	1959	1959-VI-15	15
CMN 008152	Elk Creek Power House		1959	1959-VII-07	1
CMN 008945	Elk Creek Power House		1959	1959-VII-07	1
CMN 008042	Silver Creek, 7 mi. S of Hope	49°20′N, 121°28′W	1959	1959-VII-09	2
Cameron 1986	Locality 7; =Cheam Lake Regional Park	49°11.9′N, 121°45.0′W	1984		2
Cameron 1986	Locality 8; =Bridal Veil Falls Prov. Park	49°11.1′N, 121°44.5′W	1984		2
Ovaska *et al.* 2001; RBCM 000-099-001	Bridal Veil Falls Provincial Park	49°11.1′N, 121°44.5′W	2000	22-IV-2000	5

Museum No./ Published record	Site	Geoposition	Year	Date	Number Individuals /specimens
Ovaska *et al.* 2001	Near Yarrow, Chilliwack	49°04.7'N, 122°02.5'W	2000	22-IV-2000	3
Ovaska *et al.* 2001; RBCM 000-104-001	Near Cheam Lake	49°11.9'N, 121°45.0'W	2000	22-IV-2000	1
Ovaska *et al.* 2001	Herrling Island Road	49°14.8'N, 121°45.0'W	2000	22-IV-2000	1
Ovaska *et al.* 2001; RBCM 000-103-001	Hopyard Hill, Agassiz	49°13.99'N, 121°46.98'W	2000	23-IV-2000	2
Ovaska *et al.* 2001	Cemetary Hill, Agassiz	49°14.21'N, 121°48.11'W	2000	23-IV-2000	9
Ovaska *et al.* 2001; RBCM 000-102-001	Nicomen Slough, Hodgekins Rd.	49°12.51'N, 122°00.44'W	2000	23-IV-2000	1
Ovaska *et al.* 2001; RBCM 000-101-001	Warton Creek, Neilson Regional Park, Mission	49°09.5'N, 122°14.9'W	2000	23-IV-2000	3
Ovaska *et al.* 2001	Nicomen Island, 900 m SW of Deroche	49°10.74'N, 122°04.50'W	2000	23-IV-2000	1
Ovaska *et al.* 2001; RBCM	Tamihi Creek, Chilliwack Valley	49°04.25'N, 121°50.46'W	2000	30-IV-2000	6
Ovaska *et al.* 2001	Trinity Western University, Langley	49°08.3'N, 122°35.7'W	2001	08-IX-2001	5
Ovaska *et al.* 2001	Warton Creek, Neilson Regional Park, Mission	49°09.5'N, 122°14.9'W	2001	09-VI-2001	
Ovaska *et al.* 2001	St. Mary's Park, W side of D'Herbomez Creek, Mission	49°08.5'N, 122°16.9'W	2001	09-VI-2001	2
Field Museum of Natural History 146670	Agassiz			?	1
Dall 1905; repeated by La Rocque 1953	Chilliwack Lake			?	?
Dall 1905; repeated by La Rocque 1953	Sumas Prairie			?	?
Whiteaves 1906 as *Polygyra ptychophora*; USNM?	Mission Junction			?	?

Appendix 2. Geographic Information System (GIS) mapping exercise overlaying known Oregon Forestsnail occurrence records with projected urban growth boundary layers in the Fraser Valley Regional District.

The core areas of natural habitat remaining within the geographic range of Oregon Forestsnail in Canada are within the municipalities of Abbotsford, Chilliwack, Harrison Hot Springs, Hope, Kent, District of Langley and Mission. Together, these municipalities, in part, form the Fraser Valley Regional District (FVRD).

The FVRD, including all municipal governments within the boundaries, began their urban growth strategy in 1996 and finalized their Regional Growth Strategy in 2004. Within the FVRD Regional Growth Strategy there are urban growth boundaries (Table 2.1) which aim to contain urban growth. It is expected that within a 20 – 30 year time frame (2004–2034) these areas will be highly developed as urban centres within the FVRD. At present, the amount of urban growth (non-natural habitat) within these areas is not mapped, but it can be assumed only habitat not within the Agricultural Land Reserve or within protected areas, is targeted for urban growth.

Table 2.1. Amount of area contained within urban growth boundaries of the Fraser Valley Regional District (FVRD).

FVRD Municipalities	Area within urban growth boundaries (ha)
Abbotsford	7587
Chilliwack	4405
Harrison Hot Springs	343
Hope	713
Kent	718
Langley (District of)	2
Mission	3370
Total	17,138

For this exercise, known Oregon Forestsnail occurrence records from the BC Conservation Data Centre were overlaid with urban growth boundary layers. In the Lower Mainland and Lower Fraser Valley, Oregon Forestsnail is recorded from Burnaby to Hope, with the majority of records being from the FVRD (Figure 2.1). Each municipality within the FVRD has a defined "urban growth boundary" – a geographic area where the municipality will focus approvals for increased development and urban growth densification (e.g., housing, commercial, industrial, etc.) (Figure 2.2). These become human population centres.

Each municipality has separate bylaws that require development proposals to consider environmental values such as species at risk. Abbotsford has some of the most stringent environmental bylaws in the province, and requires proponents to collect data on species at risk under specific Wildlife Assessment Report Guidelines (City of Abbotsford 2010). Therefore the best data on Oregon Forestsnail distribution as well as GIS habitat overlays is available for the Abbotsford region, which is south of the Fraser River across from Mission (Figure 2.3). The Fraser Valley Regional Growth Strategy (2004) projected development from 2004 – 2034 defines the urban growth boundary for the City of Abbotsford at 7587 ha; the urban growth boundary for Mission is 3370 ha (FVRD 2004). Some of the urban growth boundary is currently developed (e.g., housing and infrastructure) and some is currently natural land (private). Data are collected on Oregon Forestsnail distribution during development proposal planning processes in the City of Abbotsford and were used for the construction of habitat suitability maps on Sumas Mountain.

Sumas Mountain is 6600 ha and one of the last relatively intact forested areas in the Lower Fraser Valley. A total of 4570 ha (70%) of the mountain is within the Abbotsford urban growth boundary (City of Abbotsford 2010), which is 60% of the total urban growth boundary for Abbotsford (Table 2.1). The suitability of habitat for Oregon Forestsnail was mapped for 3900 ha (59%) of Sumas Mountain (City of Abbotsford 2010; Bettles pers. comm. 2013; Durand pers. comm. 2013) (Figure 2.4). Within the mapped study area of Sumas Mountain there are 624 known occurrences of the Oregon Forestsnail (City of Abbotsford 2010). Habitat suitability for the snail is based on sensitive ecosystem mapping information (Durand pers. comm. 2013) and was divided into four categories:

high = snail presence, older > 50 years, broadleaf forest;

moderate = some polygons have snails, younger disturbed broadleaf forest but with natural forest attributes;

low = very few to no snail presence, natural but disturbed areas;

nil = urban development and no possibility of snail habitat

GIS was used to overlay the Abbotsford urban growth boundary onto the mapped mollusc suitability on Sumas Mountain (City of Abbotsford 2010). A total of 465 ha of the mapped area within the urban growth boundary of Abbotsford is considered to have high suitability for the snail (Figure 2.4). Similarly, 41 ha has moderate, 82 ha has low, and 499 ha has no suitability, likely because this land is already developed. This means that 47% of the 1087 ha of mapped habitat on Sumas Mountain within the urban growth boundary of Abbotsford has high or moderate suitability for Oregon Forestsnail and can be expected to be lost when urban development occurs from 2004-2034. However, only 14% (or 1087 ha) of the total 7587 ha within the urban growth boundary of Abbotsford has been mapped for suitability for Oregon Forestsnail.

The District of Mission also requires development to consider Oregon Forestsnail. The most recent example of a large urban development project was the "Wren Creek Development" (see Figures 13 and 14 in the main report), which through the development process was deemed to have high environmental values. Concern over the impacts to Oregon Forestsnail was expressed by both the Canadian Wildlife Service and BC Ministry of Forests, Lands and Resource Operations (see Scott Resource Services Inc. 2011). Wren Creek development received final approval on 16 April 2012 (MacNair 2012) despite the presence of Oregon Forestsnail.

Urban growth boundaries for the areas around Chilliwack also contain polygons mapping known Oregon Forestsnail sites (Figure 2.5). While the polygon showing the known Oregon Forestsnail site around Hope are outside the urban growth boundary (Figure 2.6), there are known Oregon Forestsnail sites within the urban growth boundary near Kent (Figure 2.7). Similar to Abbotsford (Figure 2.3), point records for Oregon Forestsnail within the urban growth boundaries of these cities also are not available.

While the overall amount of habitat loss that has occurred in the past and is projected to occur into the future over the entire range of Oregon Forestsnail is untallied, it can be concluded that all areas within the urban growth boundary are slated for future land conversion and development. This development will eliminate most large contiguous Oregon Forestsnail habitats, and the small pieces of habitat that remain as part of municipal set-aside requirements, riparian corridors, or compensation are likely to be sinks with snail populations declining to or nearly to zero in the short term (< 10 years).

If development occurs within the entire urban growth boundaries (Table 2.1) of the FVRD, a 171.38 km^2 reduction in natural habitat can be expected within the next 30 years. It is currently not possible, given the available data, to quantify the effects of this urban development on reductions in EO, IAO, number of populations, and number of mature individual Oregon Forestsnail; however, the outlook is not good.

References (in addition to those in main body of report):

Bettles, T., pers. comm. 2013. *Personal communication to Jennifer Heron (phone and email).* February 21, 2013. Environmental Coordinator, City of Abbotsford, British Columbia.

City of Abbotsford. 2010. Sensitive Ecosystem Inventory Mapping project. Completed by R. Durand for the City of Abbotsford, BC. Summary report available at http://www.abbotsford.ca/Assets/Abbotsford/Dev+Services+-+Planning+and+Environment/environmental/Sensitive+Ecosystem+Inventory+Mapping+for+Sumas+Mountain+2010.pdf [accessed 22 February 2013].

City of Abbotsford Wildlife Assessment Report Guidelines. 2010. Available at http://www.abbotsford.ca/Assets/Abbotsford/Dev+Services+-+Planning+and+Environment/environmental/Wildlife+Assessment+Guidelines.pdf [accessed February 19, 2013].

Durand, R., pers. comm. 2013. *Personal communication to Jennifer Heron (phone and email)*. February 19, 2013. Biologist, Taara Environmental, Crescent Valley, British Columbia.

Fraser Valley Regional District (FVRD). 2004. Fraser Valley Regional District Growth Strategy. Available at http://www.fvrd.bc.ca/Services/RGS/Pages/default.aspx [accessed February 15, 2013]

MacNair, A. 2012. Wren Creek development receives approval despite opposition. Newspaper article in the Mission City Record available at http://www.missioncityrecord.com/news/147780975.html [accessed February 19, 2013].

Scott Resources Services Inc. 2011. Letter to Mayor and Council, District of Mission. Adoption of agenda item to Regular Council Meeting, 17 October 2011. Web site: http://www.mission.ca/wp-content/uploads/late-items-oct-17.pdf [accessed 19 February 2013].

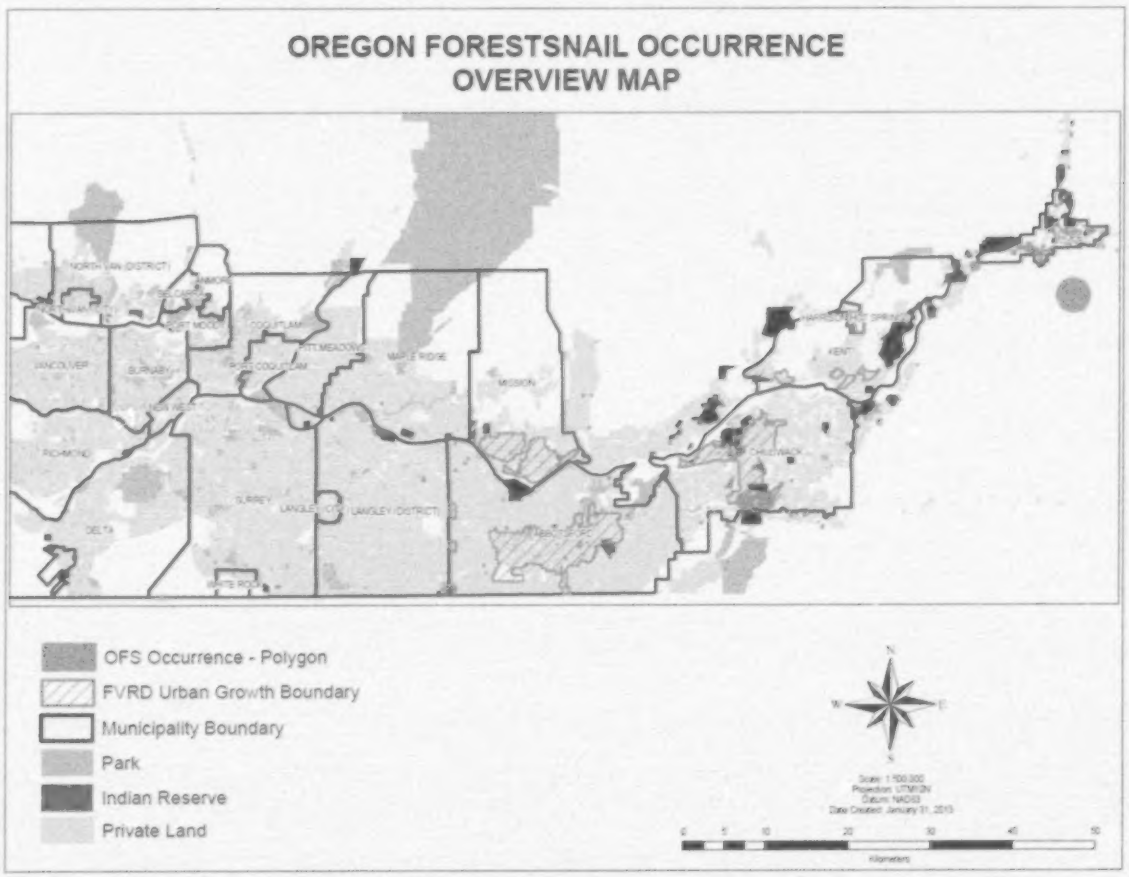

Figure 2.1. Municipalities in the Lower Mainland and Lower Fraser Valley, with Oregon Forestsnail records (habitat polygon data, BC Conservation Data Centre 2013 – note: large circular polygons represent occurrences with low representational accuracy). Oregon Forestsnail occurs within two regional government districts: Metro Vancouver (Burnaby, Delta, Surrey, White Rock, Coquitlam, Maple Ridge) and Fraser Valley Regional District (Langley, Abbotsford, Mission, Chilliwack, Kent, Harrison Hot Springs and Hope).

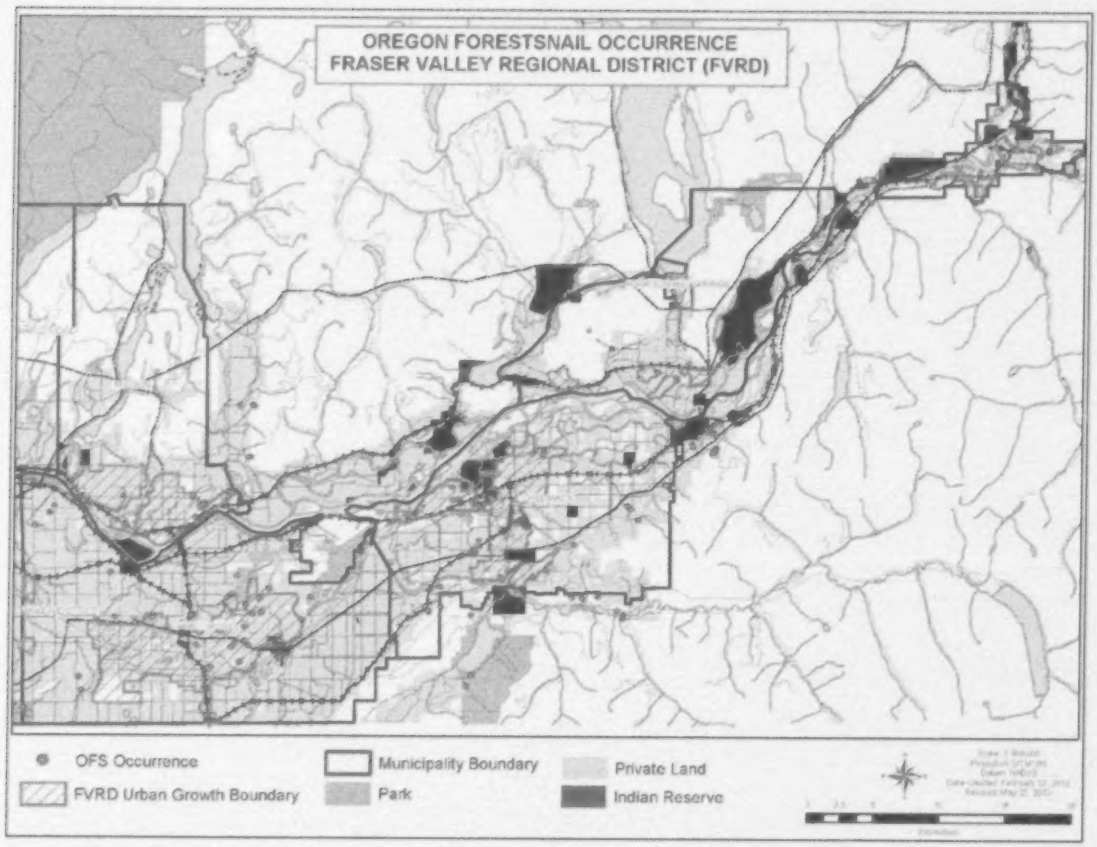

Figure 2.2. Overview range map of Oregon Forestsnail in the Fraser Valley Regional District (FVRD). FVRD is made up of numerous municipalities including Abbotsford, Langley (District), Mission, Chilliwack, Hope, Kent, Harrison Hot Springs (and others) with Oregon Forestsnail records (BC Conservation Data Centre 2013).

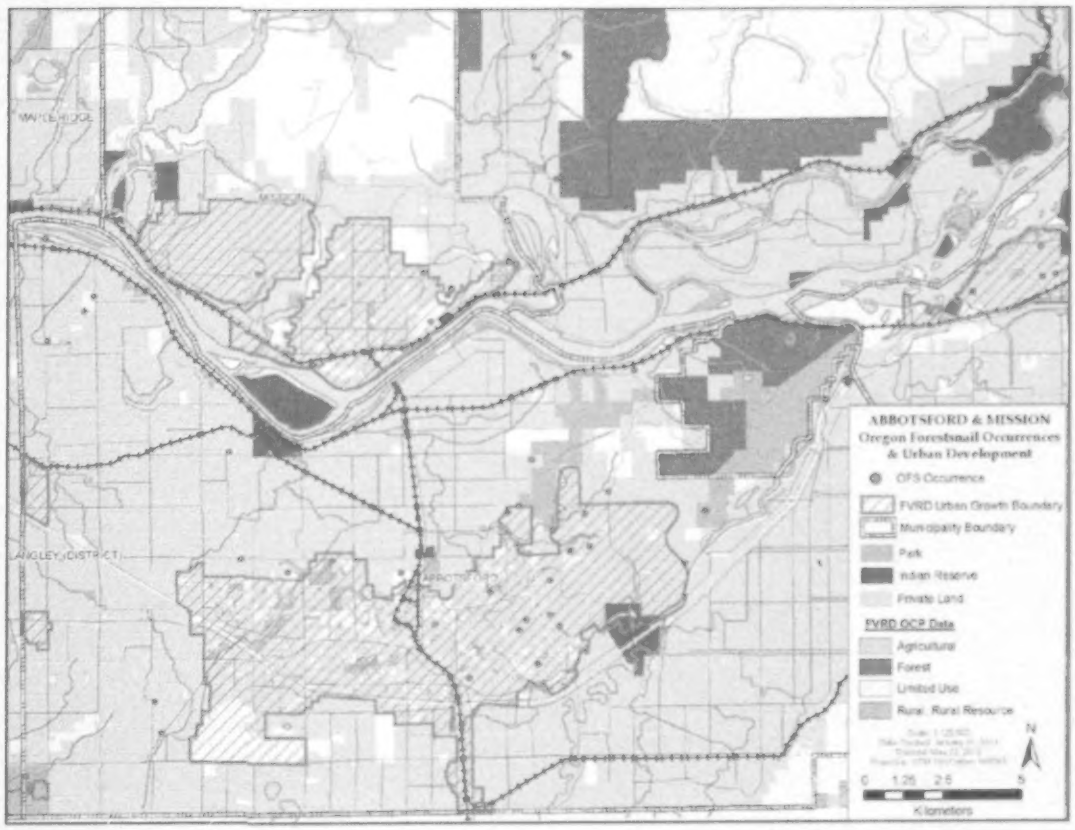

Figure 2.3. Urban growth boundaries of Abbotsford and Mission, showing Oregon Forestsnail occurrences (BC Conservation Data Centre 2013). Abbotsford urban growth boundary is 7587 ha and Mission 3370 ha, projected for development from 2004 – 2034 (FVRD 2004). The green patch extending northwest of the urban growth boundary for Abbotsford includes Sumas Mountain.

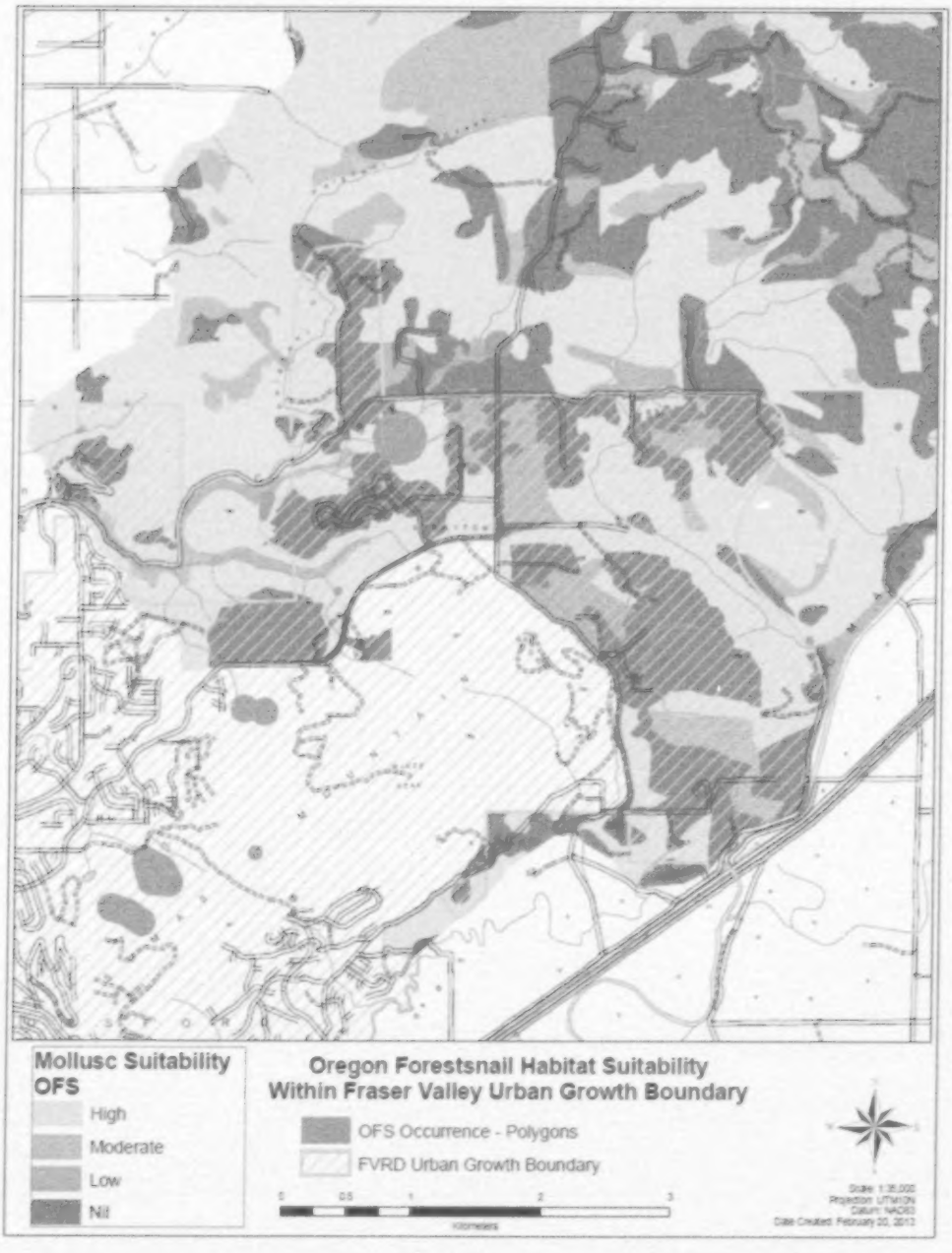

Figure 2.4. Suitability of habitat for Oregon Forestsnail within the urban growth boundary of Abbotsford on Sumas Mountain (City of Abbotsford 2010; Bettles pers. comm. 2013; Durand pers. comm. 2013).

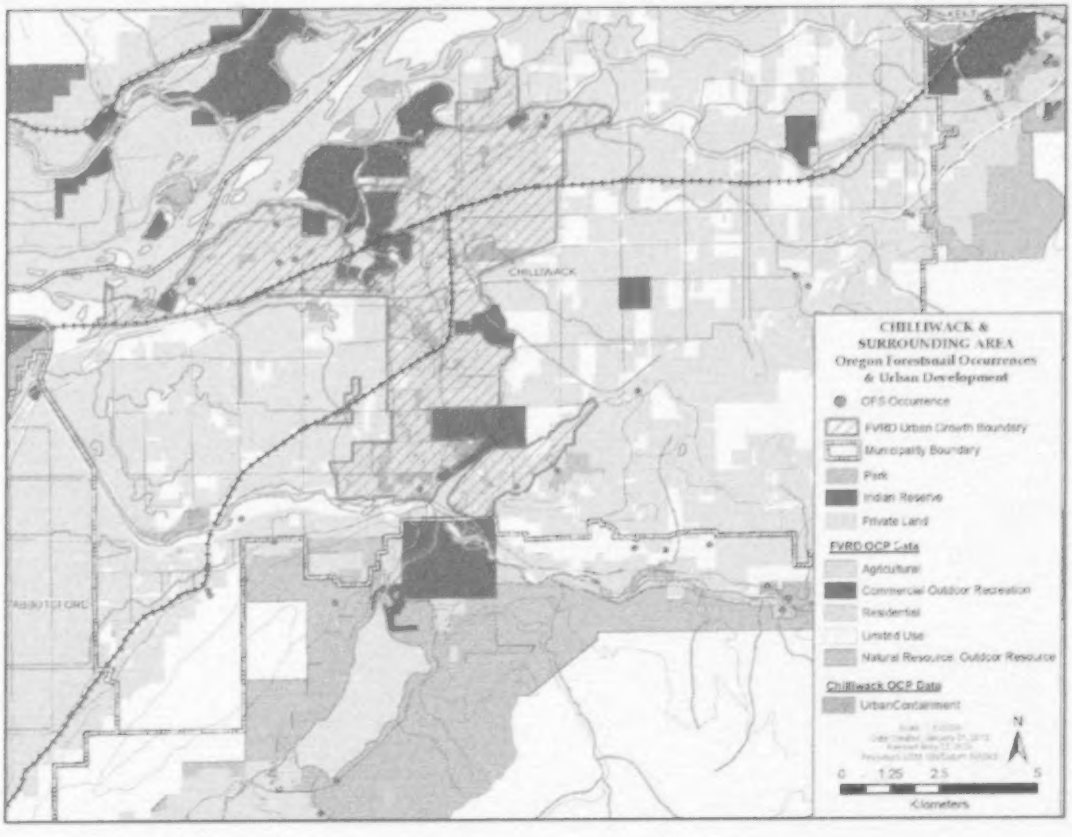

Figure 2.5. Urban growth boundaries of Chilliwack and surrounding areas, showing Oregon Forestsnail occurrences (BC Conservation Data Centre 2013). Chilliwack urban growth boundary is 4405 hectares, projected for development from 2004 – 2034 (FVRD 2004).

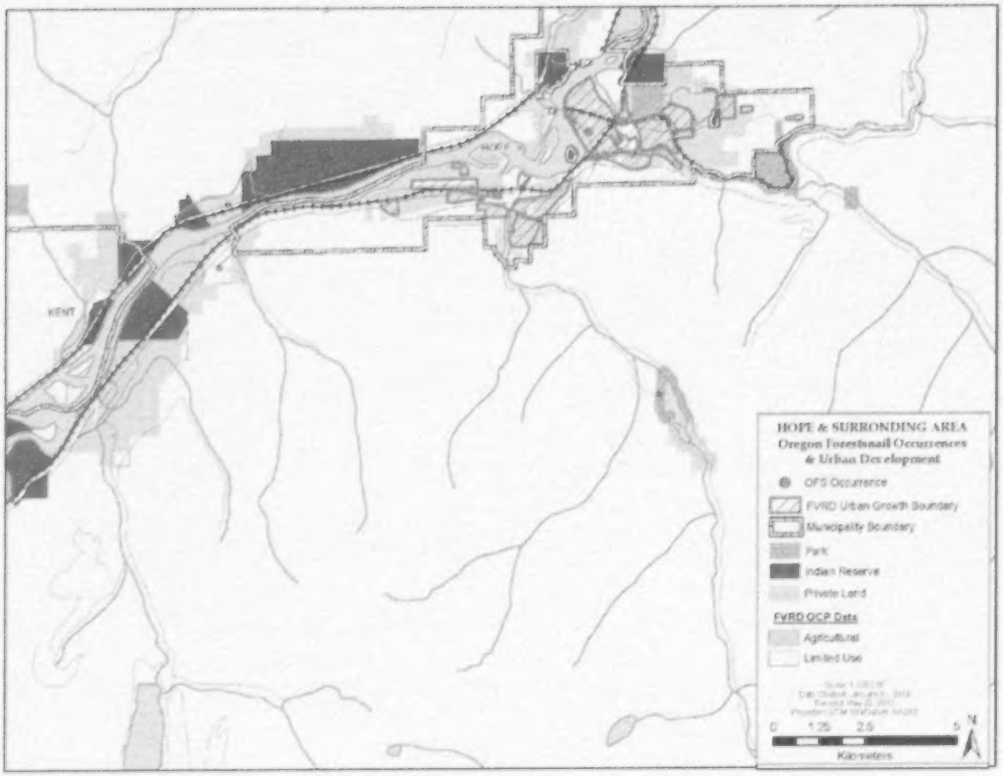

Figure 2.6. Urban growth boundaries of Hope and surrounding areas, showing Oregon Forestsnail occurrences (BC Conservation Data Centre 2013). Hope urban growth boundary is 713 hectares, projected for development from 2004 – 2034 (FVRD 2004).

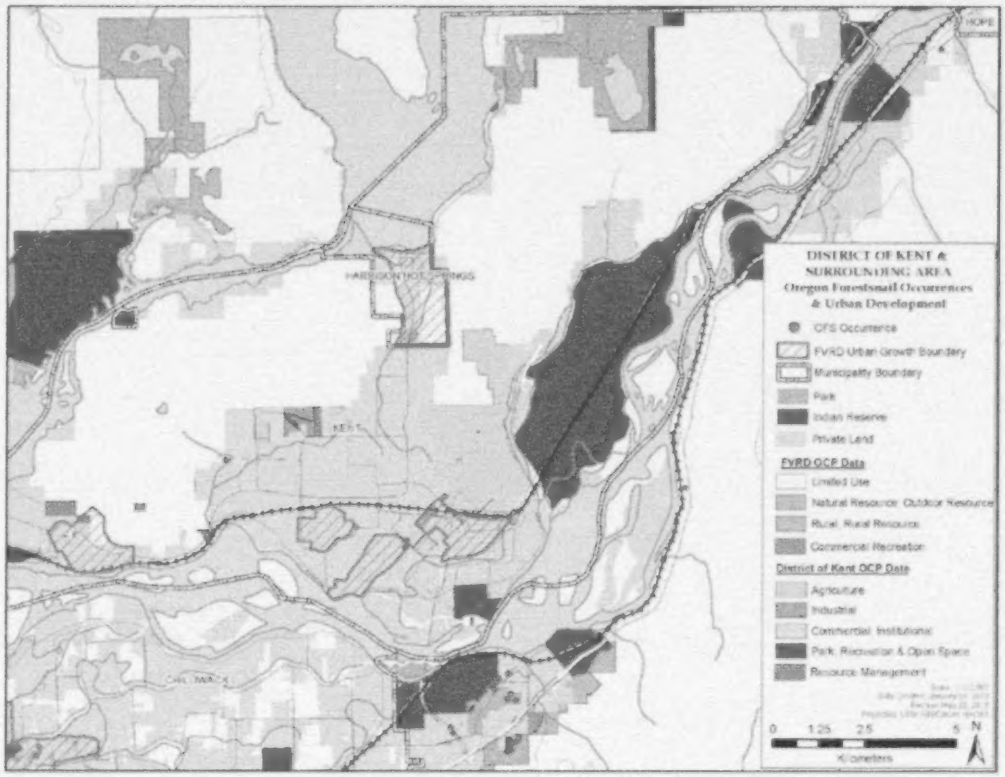

Figure 2.7. Urban growth boundaries of Kent and surrounding areas, showing Oregon Forestsnail occurrences (BC Conservation Data Centre 2013). Kent urban growth boundary is 718 hectares, projected for development from 2004 – 2034 (FVRD 2004).